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(S) Coated hard-alloy blade member.

 \odot A coated hard alloy blade member is disclosed which includes a substrate formed of a hard alloy of a WC-based cemented carbide or a TiCN-based cermet, and a hard coating deposited on the substrate. The hard coating includes an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al₂O₃ having a crystal form x or $x + \alpha$ wherein $x > \alpha$. The resulting blade member is highly resistant to wear and fracturing, and possesses cutting ability of a higher level.

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to coated hard alloy blade members or cutting tools having exceptional steel and cast iron cutting ability for both continuous and interrupted cutting.

Background Art

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Until now, the use of a coated cemented carbide cutting tool made by using either chemical vapor deposition or physical vapor deposition to apply a coating layer of an average thickness of 0.5-20 µm comprised of either multiple layers or a single layer of one or more of titanium carbide, titanium nitride, titanium carbonitride, titanium oxycarbide titanium oxycarbonitride, and aluminum oxide (hereafter indicated by TiC, TiN, TiCN, TiCNO, and Al₂O₃) onto a WC-based cemented carbide substrate for cutting steel or cast iron has been widely recognized.

The most important technological advance that led to the wide usage of the above-mentioned coated cemented carbide cutting tool was, as described in Japanese Patent Application No. 52-46347 and Japanese Patent Application No. 51-27171, the development of an exceptionally tough substrate wherein the surface layer of a WC-based cemented carbide substrate included a lot of Co, a binder metal, in comparison with the interior, whereby the fracture resistance of the coated cemented carbide cutting tool rapidly improved.

In addition, as disclosed in Japanese Patent Application No. 52-156303 and Japanese Patent Application No. 54-83745, the confirmation that, by sintering the WC-based cemented carbide containing nitrogen in a denitrifying atmosphere such as a vacuum, the surface layer of the WC-based cemented carbide substrate can be made from WC-Co which does not include a hard dispersed phase having a B-1 type crystal structure, whereby it is possible to cheaply produce WC-based cemented carbide having more Co in its surface layer than in the interior, was also important.

Concerning the advancement of the coating layer, coated cemented carbides having coating layers wherein the X-ray diffraction peaks of the Ti compounds such as TiC, TiN, and TiCN have a strong (200) orientation and the Al_2O_3 has an α -type crystal structure such as described in Japanese Patent Application No. 61-231416 and coated cemented carbides having coating layers wherein the X-ray diffraction peaks of the Ti compounds such as TiC, TiN, and TiCN have a strong (220) orientation and the Al_2O_3 has a α -type crystal structure such as described in Japanese Patent Application No. 62-29263 have little variation in the tool life.

Furthermore, Japanese Patent Application No. 2-156663 shows that a coated cemented carbide having a coating layer wherein the TiC has a strong (111) orientation and the Al_2O_3 is of the x-type has the features that there is less spalling of the coating layer and has a long life.

However, since the Ti compounds such as TiC of Japanese Patent Application No. 61-231416, Japanese Patent Application No. 62-29263, and Japanese Patent Application No. 2-156663 are coated by the normal CVD method, the crystal structure is in a granular form identical to the coating layers of the past, and the cutting ability was not always satisfactory.

Additionally, Japanese Patent Application No. 50-16171 discloses that coating is possible with the use of organic gas for a portion of the reaction gas, at a relatively low temperature. In this patent, the crystal structure of the coating layer is not described, and furthermore, the crystal structure may have a granular form, or the crystals may grow in one direction (elongated crystals) depending on the coating conditions. Moreover, in the references given in this patent, the coating layer is made up of only TiCN, and Al₂O₃ is not disclosed. Additionally, this TiCN had a low bonding strength with the substrate.

SUMMARY OF THE INVENTION

In recent years cutting technology has shown remarkable progress towards unmanned, high speed processes. Therefore, tools which are highly resistant to wear and fracturing are required. Consequently, the present inventors conducted research to develop a coated cemented carbide cutting tool having cutting ability of a higher level.

It was discovered that by coating the surface of a WC-based cemented carbide substrate and a TiCN-based cermet substrate with TiCN having crystals growing in one direction (elongated crystals) as an inner layer, and coating with Al_2O_3 having a crystal structure x or $x + \alpha$ wherein $x > \alpha$ as an outer layer, remarkable steel and cast iron cutting ability was shown for both continuous cutting and interrupted cutting.

Thus, the coated hard alloy blade member in accordance with the present invention comprises a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, the hard coating including an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al_2O_3 having a crystal form x or $x + \alpha$ wherein $x > \alpha$.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a photograph of a coated cemented carbide blade member in accordance with the present invention as taken by a scanning electron microscope.

DETAILED DESCRIPTION OF THE INVENTION

The coated hard alloy blade member or cutting tool in accordance with the present invention will now be described in detail.

As mentioned before, the coated hard alloy blade member in accordance with the present invention comprises a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, the hard coating including an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al₂O₃ having a crystal form x or x + α wherein x > α .

In order to practicalize the present invention, it is first necessary to coat the substrate with elongated crystal TiCN having high bonding strength. If the conditions are such that, for example, during the coating of the TiCN, the percentages of the respective volumes are: TiCl4: 1-10%, CH₃CN: 0.1-5%, N₂: 0-35%, H₂: the rest, the reaction temperature is 800-950 °C, the pressure is 30-500 Torr, and furthermore, the CH₃CN gas is decreased to 0.01-0.1% at the beginning of the coating as a first coating reaction for 1-120 minutes, then the CH₃CN gas is increased to 0.1-1% as a second coating reaction, then elongated crystal TiCN having high bonding strength can be obtained. The thickness of the TiCN coating layer should preferably be 1-20 μ m. This is because at less than 1 μ m the wear resistance worsens, and at more than 20 μ m the fracture resistance worsens.

Furthermore, during the coating of the TiCN, if the reaction temperature or the amount of CH₃CN is increased, the (200) plane component of the X-ray diffraction pattern of the TiCN becomes weaker than the (111) and (220) plane components, the bonding strength with the Al_2O_3 in the upper layer which has x as its main form increases, and the wear resistance goes up.

Next, Al_2O_3 of x form or $x + \alpha$ form wherein form $x > \alpha$ is coated. For coating Al_2O_3 which has x as its principal form, the conditions should be such that, for example, the reaction gas is made up of the following volume percentages in the first 1-120 minutes: $AlCl_3$: 1-20%, HCl: 1-20% and/or H_2S : 0.05-5% as needed, and H_2 : the rest, and a first reaction be performed, then afterwards, a second reaction is performed in which $AlCl_3$: 1-20%, CO_2 : 0.5-30%, HCl: 1-20% and/or H_2S : 0.05-5% as needed, and H_2 : the rest, with the conditions of a reaction temperature of 850-1000 °C and pressure of 30-500 Torr.

The thickness of this Al₂O₃ coating layer should preferably be 0.1-10 μm. At less than 0.1 μm the wear resistance worsens, while at over 10 μm the fracturing resistance worsens.

The combined thickness of the first TiCN layer and the second Al₂O₃ layer should preferably be 2-30 um

The K ratio of the $x + \alpha \text{ Al}_2\text{O}_3$ of the present invention uses a peak from Cu- $x\alpha$ X-ray diffraction, and is determined the following equation, wherein if $x > \alpha$ then the x ratio is over 50%.

$$I_{\kappa 2.79} + I_{\kappa 1.43}$$

 $\kappa \text{ ratio } (\%) = ---- \times 100$
 $I_{\kappa 2.79} + I_{\kappa 1.43} + I_{\alpha 2.085} + I_{\alpha 1.601}$

wherein

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The height of the X-ray diffraction peak for ASTM No. 4-0878 with a plane index spacing of d = 2.79

 $I_{a1.43}$: The height of the X-ray diffraction peak for ASTM No. 4-0878 with a plane index spacing of d = 1.43

I_{a2.085}: Th

The height of the X-ray diffraction peak for ASTM No. 10-173 with a plane index spacing of

d = 2.085 (the (113) plane)

la 1.601:

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The height of the X-ray diffraction peak for ASTM No. 10-173 with a plane index spacing of d = 1.601 (the (116) plane)

As further modified embodiments of the present invention, the following are included.

- (1) As an outermost layer, either one or both of TiN or TiCN may be coated on the outer Al_2O_3 layer. The reason for this coating layer is to discriminate between areas of use, and a thickness of 0.1-2 μm is preferable.
- (2) As an innermost layer, either one or more of TiN, TiC, or TiCN (granular form) may be coated underneath the inner TiCN layer. By coating with this innermost layer, the bonding strength of the elongated crystal TiCN improves and the wear resistance improves. The most preferable thickness for this coating is $0.1-5~\mu m$.
- (3) Between the inner TiCN layer and the outer Al_2O_3 layer, either one or more of TiN, TiC, or TiCN (granular form) may be coated as a first intermediate layer. This first intermediate layer improves the wear resistance during low speed cutting. However, during high speed cutting, it worsens the wear resistance. The most preferable thickness for this first intermediate layer is 1-7 μ m.
- (4) Between the inner TiCN layer and the outer Al_2O_3 layer, either one or both of TiCO, TiCNO is coated as a second intermediate layer. This second intermediate layer increases the bonding strength between the elongated crystal TiCN and the x or x + α form Al_2O_3 . The most preferable thickness of this second intermediate layer is 0. 1-2 μ m.
- (5) It is possible to combine the above-mentioned (1)-(4) as appropriate.
- (6) The inner layer coated with elongated crystal TiCN may be divided by one or more TiN layers to define a divided TiCN layer. This divided TiCN layer is less susceptible to chipping, and the fracture resistance improves.
- (7) With the divided elongated TiCN described above and the x or $x + \alpha$ form Al_2O_3 , it is possible to coat with an outermost layer of one or both of TiN or TiCN as in (1) above, coat with an innermost layer of one or more of TiN, TiC, or TiCN as in (2) above, coat with a first intermediate layer of one or more of TiC, TiN, or TiCN as in (3) above, coat with a second intermediate layer of one or both of TiCO or TiCNO as in (4) above, or to take a combination of them.
- 30 (8) The most preferable composition of the WC-based cemented carbide substrate is, by the percentage of weight, as follows:

Co: 4-12%	Ti: 0-7%	Ta: 0-7%
Nb: 0-4%	Cr: 0-2%	14.07%
N: 0-1%	W and C: the rest	

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Unavoidable impurities such as O, Fe, Ni, and Mo are also included.

(9) For the WC-based cemented carbide of the present invention, for lathe turning of steel, it is preferable that the cemented carbide be such that the amount of Co or Co + Cr in the surface portion (the highest value from the surface to within 100 μm) be 1.5 to 5 times the amount in the interior (1 mm from the surface), and for lathe turning of cast iron, it is preferable that there is no enrichment of the Co or Co + Cr, and that the amount of Co or Co + Cr be small. Furthermore, in the case of steel milling, cemented carbide in which there has been no enrichment of the Co or Co + Cr, and the amount of Co or Co + Cr is large, is preferable.

(10) The most preferable composition of the TiCN-based cermet substrate is, by the percentage of weight, as follows:

Co: 2-14%	Ni: 2-12
Nb: 0.1-10%	W: 5-30
N: 2-8%	Ti and C
Cr, V, Zr, Hf: 0-5%	

2% Ta: 2-20% Mo: 5-20% C: the rest

Unavoidable impurities such as O and Fe are included.

(11) In the TiCN-based cermet of the present invention, the substrate surface layer (the largest value within 100 µm of the surface) should be 5% or more harder than the interior (1 mm from the surface) or there should be no difference between the hardnesses of the surface layer and the interior.

The present invention will be explained in more detail by way of the following examples.

EXAMPLE 1

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As the raw materials, medium grain WC powder having an average particle size of 3 μ m, 5 μ m coarse grain WC powder, 1.5 μ m (Ti, W)C (by weight ratio, TiC/WC = 30/70) powder 1.2 μ m (Ti, W)(C, N) (TiC/TiN/WC = 24/20/56) powder, 1.5 μ m Ti(C, N) (TiC/TiN = 50/50) powder, 1.6 μ m (Ta, Nb)C (TaC/NbC=90/10) powder, 1.8 μ m TaC powder, 1.1 μ m Mo₂C powder, 1.7 μ m ZrC powder, 1.8 μ m Cr₃C₂ powder, 2.0 μ m Ni powder, 2.2 μ m NiAl (Al: 31% by weight) powder, and 1.2 μ m Co powder were prepared, then these raw material powders were blended in the compositions shown in Table 1 and wetmixed in a ball mill for 72 hours. After drying, they were press-shaped into green compacts of the form of ISO CNMG 120408 (cemented carbide substrates A-D, cermet substrates F-G) and SEEN 42 AFTN 1 (cemented carbide substrates E and E'), then these green compacts were sintered under the conditions described in Table 1, thus resulting in the production of cemented carbide substrates A-E, E' and cermet substrates F-G.

Experimental values taken at over 1 mm from the surface of the sintered compacts of the cemented carbide substrates A-E, E' and the cermet substrates F-G are as shown in Table 2.

Furthermore, in the case of the above cemented carbide substrate B, after maintenance in an atmosphere of CH₄ gas at 100 torr and a temperature of 1400 °C for 1 hour, a gradually cooling carburizing procedure was run, then, by removing the carbon and Co attached to the substrate surface using acid and barrel polishing, a Co-rich region 40 µm deep was formed in the substrate surface layer wherein, at a position 10 µm from the surface the maximum Co content was 15% by weight.

Additionally, in the case of cemented carbide substrates A and D above, while sintered, a Co-rich region 20 μ m deep was formed wherein, at a position 15 μ m from the surface, the maximum Co content was 11% and 9% by weight, respectively, and in the remaining cemented carbide substrates C, E and E', no Co-rich region was formed, and they had similar compositions over their entirety.

In the above cermet substrates F and G, in the sintered state, a surface layer harder than the interior existed. The hardnesses at the surface and 1 mm below the surface for the cermet substrates F and G are shown in Table 2.

Next, after honing the surfaces of the cemented carbide substrates A-E, E' and cermet substrates F and G, by forming coating layers under the special coating conditions shown in Tables 3(a) and 3(b) and having the compositions, crystal structures, orientation of TiCN (shown, starting from the left, in the order of the intensity of the corresponding X-ray diffraction peak) and average thicknesses shown in Table 4 by using a chemical vapor deposition apparatus, the coated cemented carbide cutting tools of the present invention 1-12 and 15-26, the coated cermet cutting tools of the present invention 13, 14, 27, and 28, the coated cemented carbide cutting tools of the prior art 1-12 and 15-26, and the coated cermet cutting tools 13, 14, 27, and 28 of the prior art were produced.

Then, for the coated cemented carbide cutting tools of the present invention 1-10 and 15-24, and the coated cemented carbide cutting tools of the prior art 1-10 and 15-24, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 270 m/min

Feed: 0.25 mm/rev
Depth of Cut: 2 mm

Cutting Time: 30 min

in which a determination was made whether or not the cutting failed due to tears made in the workpiece because of chipping of the cutting blade or spalling of the coating layer. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 250 m/min

Feed: 0.25 mm/rev
Depth of Cut: 1.5 mm
Cutting Time: 40 min

in which a determination was made whether or not the cutting failed due to trouble such as fracturing or chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured.

For the coated cemented carbide cutting tools of the present invention 11, 12, 25 and 26, and the coated cemented carbide cutting tools of the prior art 11, 12, 25 and 26, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 250 m/min

Feed: 0.35 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

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in which a determination was made whether or not the milling failed due to trouble such as chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured.

For the coated cermet cutting tools of the present invention 13, 14, 27 and 28, and the coated cermet cutting tools of the prior art 13, 14, 27 and 28, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 320 m/min

Feed: 0.25 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

20 in which a determination was made whether or not the cutting failed due to chipping or fracturing of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 300 m/min

Feed: 0.20 mm/rev

Depth of Cut: 1 mm Cutting Time: 20 min

in which a determination was made whether or not the cutting failed due to trouble such as chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured.

The results of the above tests are shown in Tables 4-7. As is able to be seen from Tables 4-7, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 2

Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 8 and 9, the coated cemented carbide cutting tools of the present invention 29-40, the coated cermet cutting tools of the present invention 41 and 42, the coated cemented carbide cutting tools of the prior art 29-40, and the coated cermet cutting tools 41 and 42 of the prior art were produced.

Then, for the coated cemented carbide cutting tools of the present invention 29-38, and the coated cemented carbide cutting tools of the prior art 29-38, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 250 m/min

Feed: 0.27 mm/rev Depth of Cut: 2 mm

Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

55 Cutting Speed: 230 m/min

Feed: 0.27 mm/rev Depth of Cut: 1.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

For the coated cemented carbide cutting tools of the present invention 39 and 40, and the coated cemented carbide cutting tools of the prior art 39 and 40, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 230 m/min Feed: 0.37 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

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and an appraisal identical to that of Example 1 was made.

For the coated cermet cutting tools of the present invention 41 and 42, and the coated cermet cutting tools of the prior art 41 and 42, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

75 Cutting Speed: 300 m/min

Feed: 0.27 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was

Workpiece: mild steel round bar with groove

Cutting Speed: 280 m/min

Feed: 0.22 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

The results of the above tests are shown in Tables 8, 9(a) and 9(b). As is able to be seen from Tables 8, 9(a) and 9(b), all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 3

Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thickness shown in Tables 10-13, the coated cemented carbide cutting tools of the present invention 43-54 and 57-68, the coated cermet cutting tools of the present invention 55, 56, 69 and 70, the coated cemented carbide cutting tools of the prior art 43-54 and 57-68, and the coated cermet cutting tools 55, 56, 69 and 70 of the prior art were produced. Figure 1 shows a photograph of the surface layer of the coated cemented carbide cutting tool of the present invention as taken by a scanning electron microscope.

Then, for the coated cemented carbide cutting tools of the present invention 43-52 and 57-66, and the coated cemented carbide cutting tools of the prior art 43-52 and 57-66, a mild steel continuous cutting test was performed under the following conditions.

Workpiece: mild steel round bar

Cutting Speed: 280 m/min

Feed: 0.23 mm/rev Depth of Cut: 2 mm Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 260 m/min

Feed: 0.23 mm/rev
Depth of Cut: 1.5 mm
Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

For the coated cemented carbide cutting tools of the present invention 53, 54, 67 and 68, and the coated cemented carbide cutting tools of the prior art 53, 54, 67 and 68, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 260 m/min Feed: 0.33 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

For the coated cermet cutting tools of the present invention 55, 56, 69 and 70, and the coated cermet cutting tools of the prior art 55, 56, 69 and 70, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 330 m/min

Feed: 0.23 mm/rev
Depth of Cut: 1 mm
Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 310 m/min

Feed: 0.18 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

25 and an appraisal identical to that of Example 1 was made.

The results of the above tests are shown in Tables 10-13. As is able to be seen from Tables 10-13, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

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EXAMPLE 4

Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 14-17, the coated cemented carbide cutting tools of the present invention 71-82 and 85-96, the coated cermet cutting tools of the present invention 83, 84, 97 and 98, the coated cemented carbide cutting tools of the prior art 71-82 and 85-96, and the coated cermet cutting tools 83, 84, 97 and 98 of the prior art were produced.

Then, for the coated cemented carbide cutting tools of the present invention 71-80 and 85-94, and the coated cemented carbide cutting tools of the prior art 71-80 and 85-94, a mild steel continuous cutting test was performed under the following conditions.

Workpiece: mild steel round bar Cutting Speed: 260 m/min

Feed: 0.26 mm/rev Depth of Cut: 2 mm Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 240 m/min

Feed: 0.26 mm/rev Depth of Cut: 1.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

For the coated cemented carbide cutting tools of the present invention 81, 82, 95 and 96, and the coated cemented carbide cutting tools of the prior art 81, 82, 95 and 96, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 240 m/min Feed: 0.36 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

5 and an appraisal identical to that of Example 1 was made.

For the coated cermet cutting tools of the present invention 83, 84, 97 and 98, and the coated cermet cutting tools of the prior art 83, 84, 97 and 98, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

10 Cutting Speed: 310 m/min

Feed: 0.26 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 290 m/min

Feed: 0.21 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

The results of the above tests are shown in Tables 14-17. As is able to be seen from Tables 14-17, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 5

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Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 18-21, the coated cemented carbide cutting tools of the present invention 99-112 and 122-126, the coated cermet cutting tools of the present invention 113-121, the coated cemented carbide cutting tools of the prior art 99-112 and 122-126, and the coated cermet cutting tools 113-121 of the prior art were produced.

Then, for the coated cemented carbide cutting tools of the present invention 99-112, and the coated cemented carbide cutting tools of the prior art 99-112, a mild steel high-feed continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 210 m/min

Feed: 0.38 mm/rev

Depth of Cut: 2 mm Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, a deep cut interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 210 m/min

Feed: 0.23 mm/rev Depth of Cut: 4 mm Cutting Time: 40 min

50 and an appraisal identical to that of Example 1 was made.

For the coated cemented carbide cutting tools of the present invention 122-126, and the coated cemented carbide cutting tools of the prior art 122-126, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

55 Cutting Speed: 260 m/min

Feed: 0.33 mm/tooth
Depth of Cut: 3 mm
Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

For the coated cermet cutting tools of the present invention 113-121, and the coated cermet cutting tools of the prior art 113-121, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar

Cutting Speed: 340 m/min

Feed: 0.22 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 320 m/min

Feed: 0.17 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

The results of the above tests are shown in Tables 18-21. As is able to be seen from Tables 18-21, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

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TABLE 1

Blend Composition (% by weight) Sintering Conditions	(Ti, W)C (Ti, W)CN (Ta, Nb)C Cr3C2 WC Pressure Temperature Holding	6 4 - Balance Vacuum 1380 1 (medium orașin) (0 10 rore)		-	 	-	+	TiC - 23 TiN - 10 TaC - 13 WC - 10 Mo ₂ C - 0.5 ZrC - 8 Co - Vacuum 1500 1.5 - 0.3 NiAl (0.10 torr)	ICN - 10 TaC - 1 NbC - 9 WC - 9 Mo ₂ C - 7 Co - 7 Ni Ni N2 Atmosphere
Blend Composit	(Ti. W)CN				s			TiC - 23 TiN - 10 TaC - 13 WC - 0.3 NiAl	N - 10 TaC - 1 NbC - 9 WC - 9
Туре	ပ	۷ <	8	Cemented Carbide C 9 Substrate	s a	ε 10	E. 10	F 30.2	Substrate G 57 TiC

TABLE 2

		Composition of Sintered Body (* by weight)	Наго	Hardness
			Interior (HRA)	Surface (HRA)
	۷.	6.1 Co - 2.1 Ti - 3.4 Ta - 0.4 Nb - Rest (W + C)	30.5	,
	an l	5.2 Co - 1.2 Ti - 4.2 Ta - 0.4 Nb - Rest (W + C)	91.0	,
	υ	9.0 Co - 1.9 Ti - 4.3 Ta - 0.4 Nb - Rest (W + C)	90.3	,
Cemented Carbide Substrate	۵	5.2 Co - 1.7 Ti - 2.5 Ta - 0.3 Nb - Rest (W + C)	91.1	,
	ω	9.8 Co - 1.7 Ta - 0.2 Nb - Rest (W + C)	89.7	1
	ů	9.8 Co - 0.6 Cr - Rest (W + C)	89.8	
Cermer	ű.	9.4 Ta - 12.2 W - 9.4 Mo - 0.4 Zr - 7.9 Co - 5.1 Ni - 0.1 Al - 3.8 N - Rest (Ti + C)	91.7	92.2
Substrate	U	9.5 Ta · 0.9 Nb · 8.5 W · 8.5 Hc · 7.1 Co · 7.0 Ni · 6.8 N · Rest (Ti · C)	91.6	92.6

TABLE 3 (a)

5	(Coasing Cond	licions)			
J	Composition	X-ray Orientation	Gas Composition (% by volume)	Temperature (°C)	Pressure (Torr)
10	Innermost Layer Granular TiC		TiCl ₄ :2, CH ₄ :5, H ₂ :Rest	1020	50
	Innermost Layer Granular TiN		TiCl ₄ :2, N ₂ :25. H ₂ :Rest	920	50
15	Innermost Layer Granular TiCN		TiCl ₄ :2, CH ₄ :4, N ₂ :20, H ₂ :Rest	1020	50
	Inner Layer Elongated TiCN	(111) (220) (200)	First Reaction - TiCl ₄ :2, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl ₄ :2, CH ₃ CN:0.6, N ₂ :20, H ₂ :Rest	860	50
20	Inner Layer Elongated TiCN	(220) (111) (200)	Pirst Reaction -	900	50
	Inner Layer Elongated TiCN	(111) (200) (220)	Pirst Reaction - TiCl4:2, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl4:2, CH ₃ CN:0.3, N ₂ :20, H ₂ :Rest	860	50
25	Inner Layer Elongated TiCN	(220) (200) (111)	First Reaction - TiCl ₄ :4, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl ₄ :4, CH ₃ CN:0.3, N ₂ :20, H ₂ :Rest	900	50
	Inner Layer Granular TiCN	(111) (200) (220)	TiCl4:4, CH4:6, N2:2, H2:Rest	1050	500
30	Inner Layer Granular TiCN	(220) (200) (111)	TiCl4:4. CH4:4. N2:2. H2:Rest	1050	500
	Inner Layer Granular TiCN	(200) (220) (111)	TiCl ₄ :4, CH ₄ :2, N ₂ :2, H ₂ :Resc	1000	100
35	Divided Layer Granular TiN		TiCl ₄ :2, N ₂ :25, H ₂ :Rest	900	200
	Divided Layer Granular TiN		TiCl ₄ :2, N ₂ :25, H ₂ :Rest	860	200 -
40	First Intermediate Layer Granular TiC		TiCl ₄ :2. CH ₄ :5. H ₂ :Rest	1020	50 -
	First Intermediate Layer Granular TICN		TiCl ₄ :2, CH ₄ :4. N ₂ :20, H ₂ :Rest	1020	50
45	Second Intermediate Layer Granular TiCO		TiCl ₄ :4. CO:6. H ₂ :Rest	980	50
50	Second Intermediate Layer Granular TiCNO		TiCl ₄ :4, CH ₄ :2, N2:1.5, CO ₂ :0.5, H ₂ :Rest	1000	50

TABLE 3 (b)

5	Composition	X-ray Orientation	Gas Composition (% capacity)	Temperature (°C)	Pressure (Torr)
	Outer Layer Al ₂ O ₃	100%×	First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :5%, H ₂ S:0.J, H ₂ :Rest	970	50
10	Outer Layer Al ₂ O ₃	94 % K	First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :5%, H ₂ :Rest	970	50
•	Outer Layer Al ₂ O ₃	85 % ×	First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :6%, H ₂ S:0.2, H ₂ :Rest	980	50
15	Outer Layer	73 8 K	First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :6%, H ₂ :Rest	980	50
	Outer Layer Al ₂ O ₃	62 % K	First Reaction - AlCl3:3%, H2:Rest Second Reaction - AlCl3:3%, CO2:7%, H2S:0.2, H2:Rest	990	50
20	Outer Layer Al ₂ O ₃	55 % K	First Reaction - AlCl3:3%, H2:Rest Second Reaction - AlCl3:3%, CO2:8%, H2:Rest	1000	50
	Outer Layer Al ₂ O ₃	40 1 K	First Reaction - AlCl ₃ :3%, H ₂ S:0.05, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :9%, H ₂ S:0.1, H ₂ :Rest	1010	50
25	Outer Layer	100 \ α	AlC13:3%, CO2:10%, H2:Rest	1020	100
	Outermost Layer Granular TiN		TiCl4:2. N2:30, H2:Rest	1020	200
30	Outermost Layer Granular TiN		TiCl4:2, CH4:4, N2:20, H2:Rest	1020	200

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TABLE 4

					Hard C	Hard Coating Layer				Flank Wear	i co
Туре		Substrate Symbol		Inner Layer	ar	Outer Layer	ayer	Outermost Layer	t Layer	(ww)	10
			Composition	Crystal Structure	Orientation	Composition	Crystal	Composition	Crystal	Continuous	Interrupted
	-	4	TiCN(8.4)	Elongated Growth	(111) (220) (200)	A1203(2.2)	K:941	TIN(0.5)	Granular	0.17	0.26
	~	¥	TiCN(5.5)	Elongated Growth	(220) (111) (200)	A1203 (6.2)	K: 851			0.19	0.28
	~	ď	TiCN(11.4)	Elongated Growth	(1111) (220) (200)	A1203(1.8)	K:100	TiCN- TiN(0.7)	Granular	0.19	0.31
	4	В	TiCN(8.2)	Elongared Growth	(111) (200) (220)	A1203(2.1)	K: 1001	TiN(0.4)	Granular	6.17	0.31
Coated	5	В	TiCN(5.1)	Elongaced Growth	(111) (220) (200)	A1203 (5.2)	K:738			0.21	0.26
Cement 1 ng	9	C	TiCN(10.2)	Elongated Growth	(220) (111) (200)	A1203(1.2)	K:551	Tin(0.3)	Granular	0.22	0.31
Carbide	7	c	TiCN(5.4)	Elongated Growth	(111) (200) (27)	16.01 (0.514	к:621	Tin(0.6)	Granular	0.26	0 34
Cutting	8	Q	TiCN(6.4)	Elongated Growth	(111) (220) (200)	A1203(5.7)	K:731	TiN(0.2)	Granular	0.16	0.26
1001	6	D	TiCN(3.7)	Elongated Growth	(220) (111) (220)	A1203 (8.2)	K:621			0.17	0.30
of the	10	D	TiCN(7.9)	Elongated Growth	(111) (220) (111)	A1203 (2.5)	K: 1001			0.18	0.26
Invention	:	យ	TiCN(4.2)	Elongared Growth	(220) (111) (200)	A1203 (0.5)	K: 1001			0.17	(Hilling)
	2	U	TiCN(4.0)	Elongated Growth	(111) (220) (111)	A1203 (0.4)	K:941	TiN(0.3)	Granular	0.19	(Hilling)
	7	it	7'iCN(4.6)	Elongated Growth	(520) (111) (520)	A1203 (0.4)	K: 1001	TiN(0.4)	Granular	0.16	0.29
	7	ပ	TiCN(3.2)	Elongated Growth	(111) (220) (200)	A1203 (0.8)	K:941	TiN(0.2)	Granular	0.16	6.27

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Type		Substrate		Inner Layer		Hard Coating Layer Outer Layer	ayer	Outermost Layer	Layer	Flank Wear	Wear	
		Symbo1			- 1					- 1	- 1	
	 -		Composition	Crystal Structure	Orientation	Composition	Crystal Structure	Composition	Crystal	Continuous	Interrupted	
	-	4	TiCN(8.5)	Granular	(1111) (200) (220)	A1203 (2.0)	a: 100%	Tin(0.5)	Granular	0.47	09.0	
	ŀ		- 1							(Curpping)	(Cut pping)	
	~	≺	T1CN(5.4)	Granular	(220) (200) (111)	A1203 (6.0)	α: 1004			0.52 (Chipping)	0.56	
	ŀ	-	Tickers as	1.00.00	100011000111111	10-11-0-14		40.5	1	25.0	16.11dd 11.21	
	_	ς	1100(11:3)	1810181	(077) (007) (111)	4120311.31	K: 404	TiN(0.8)	or and lar	(Chipping)	(Chipping)	
										Failure after	Failure after	
	4	æ	TiCN(8.1)	Granular	(200) (220) (111)	A1203 (2.2)	****	TIN(0.3)	Granular	12.8 min. due	7.5 min. due to	
							2007:30			to Layer	Layer	
										Separation	Separation	
										Failure after	Failure after	
	S	æ	TICN(4.9)	Granular	(111) (200) (111)	A1203 (5.2)	Q:100#			10.7 min. due	5.3 min. due to	
										to Layer	Layer	
										Separation	Separation	
								,		Failure after	Failure after	
Coated	٥	υ	TiCN(10.3)	Granular	(220) (200) (111)	A1 203 (11.1)	3000	TiN(0.4)	Granular	5.6 min. due to	0.8 min. due to	
Cemented										Layer	Fracturing	
Carbide										Separation		
Cutting										Pailure after	Failure after	
Tools of	_	U	TiCN(S.S)	Granular	(200) (220) (111)	A1203(1.1)	K: 401	TIN(0.5)	Cranular	10.4 min. due	3.2 min. due to	
Prior Art										to Layer	Fracturing	
										Separation		
								-		Failure after	Failure after	
	&	۵	TiCN(6.5)	Granular	(1111) (200) (220)	A1203(5.6)	α: 1001	TIN(0.3)	Granular	17.1 min. due	7.9 min. due to	
	I									to Chipping	Chipping	
										Failure after	Failure after	
	~	a 	T1CN(1).8)	Cranular	(220) (200) (1111)	A1203(B.4)	K: 401			15.4 min. due	5.2 min. due to	
										כס כעוסטועט	Chipping	
		,				;				Failure after	Failure after	
	2	c	TICKU 7	Granular	(022) (200) (111)	A1203 (2.4)	G: 1001			13.6 min. due	7.0 min. due to	
	=		1 AVADIT	a finder	111111000110001	19 07 00 14				co chipping	intention of	
	:	.	-		(****) (20**) (27**)	10.01 fo7.0	Q: 100			Chinaina (Milling)	ים שוטי מחב כני	
	=	i	TiCN() 9)	Granular	(1)1) (200) (220)	11.00.00.14	30,	TINED 21	Granular	Calling afrec 17 7 min de con	7 min 4.0 co	
	:	,				15:51 557	a : 100 4		181918	Taylor Copyration (4:1):00	. min. due to	
										Failure afrec	Failure avenue	
	13	14.	TiCN(4, 4)	Granular	(220) (200) (111)	A1505 (0.4)		TINCO 41	Granular	o min due re	ישוט קוופ ני	
							α: 1001		; ; ;	Chipping	Fracturing	
	L		-							Failure after	Failure afrer	
_	-	U	TICN(3.3)	Granular	(1111) (200) (220)	19.01.0514		Tin(0,3)	Granular	2.8 min due ro	o 2 min due ro	
							a:1001			Chipping	Fracturino	

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TABLE 6

Interrupted Cutting 0.28 0.27 0.20 0.16 0.22 0.19 0.18 0.15 0.14 0.20 0.21 0.17 (Brilling) (Hilling) flank Wear (mm) Cont Innous Cutting 0.13 0.13 0.15 0.15 0.20 0.13 0.16 0.15 0.18 0.16 0.17 0.17 Crystal Structure Granular Granular Granular Granular Granular Granular Granular Granular Outermost Layer Compo-sition TiN (0.8) 1.0) TICN-TIN (0.8) TiN (0.3) TiN (0.5) TiN (0.3) TiN (0.2) T. (0. 5) Crystal Structure K:1004 K: 1001 K: 948 N: 1001 K: 941 K: 941 K: 1001 K: 621 K:851 K: 100 K: 731 K: 551 K: 621 K:731 Outer Layer Compo-sition A1203 A1203 (8.1) A1203 A1203 A1203 ۸1₂0₃ (1.2) A1203 A 1 203 A1203 A1203 (6.1) A1203 A1203 (2.0) (3.4) (9.0) Hard Coating Layer (220) (200) (111) (111) (220) (200) (220) (111) (200) (111) (220) (200) (220) (111) (200) (220) (111) (200) (111) (220) (200) (220) (111) (200) (111) (220) (111) (111) (220) (200) Elongated (111) (220) (200) Growth (111) (220) (200) (220) (111) (200) (111) (200) (220) Orientation Inner Layer Elongated Elongated Elongared Growth Elongated Growth Growth Elongated Elongated Elongated Elongated Elongated Growth Elongated Growth Elongated Growth Crystal Structure Elongated Elongated Growth Growth sicion TiCN (11.2) J.S. TiCN (5.5) TiCN (4.8) TiCN (10.2) TiCN (6.5) TiCN (3.9) TiCN (7.8) 7 i C TiCN (3.5) TiCN (4.5) 71CN TiCN (8.3) TiCN (5.5) (8.2) Crystal Structure Granular Innermost Layer Compo-sition 7 i CN. TiN (0.1) 7iC (0.4) 7 C.O Tin (0.3) TiN (0.6) TiN (1.2) TiCN (0.6) 71N (0.9) Tin (0.5) TiC-TiN (1.5) Substrate Symbol ۵ ٥ ۵ ίú شا Ö Ŀ U v œ Ø 74 25 92 28 22 2.1 20 2 91 2 9 13 Invention Type Coated Tools of the Carbide Cutting

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TABLE 7 (a)

	Wear	Interrupted	Cutting	(Chipping)	0.50	(Cui pping)	(Chipping)	Failure	after 8.1	min. due to	Layer	Separation	Failure	alter 7.5	min. due to	Separation	Failure	after 1.7	min. due to	Fracturing		Failure	after 3.7	min. due to	Fracturing		Failure	after 10.1	min. due co	Chippin3	Failure	after 5.8	min. due to	Chipping	Failure	After 7.6	min. due to
	Flank Wear (mm)	12	Cutt 109	(Chipping)	0.43	in phings	(Chipping)	Failure	~.	ue to		5		min due 19.5	3	tion	1		due to	_	Separation	Failure		ue to	Layer	ĕ		~	2			_	0		_	_	Chin oue to
	Outermost Layer	Crystal	Granular			or and a		Granular									Granular					Granular											`				
	Outerm	Compo-	TIN	(0.8)	•	TiCN.	NIT (C	TIN	9.0								NIT	(0.3)				TÍN	(0.5)														
	Outer Layer	Crystal	α:100		\$100£	27.70		a: 1001				.00.	4: 100 1				a: 1001					K: 401					α: 1001				K: 401				α:100 1		
	Oute	Compo-	A1203	(2.0)	A1203	A1503	(2.1)	۸1203	(1.9)			A) 303					A1203	3.5				A1203	(6.0)			3	57.	(3.0)			A1203	(7.0)		100	1203		
Hard Coating Layer	yer	Orientation	(111) (200) (220)		(220) (200) (111)	(111) (200) (220)		(200) (220) (111)				(1111) (200) (220)					(220) (200) (111)					(700) (770) (111)				10111110001111111	10441 10041 1111			111111000110001	(1111) (002) (022)			(1111) (2001) (220)	(077) (00*) (111)		
×	Inner Layer	Crystal	Granular		Granular	Granular		Granular				Granular					Granular					re cono so			-	Granular				Granular				Granular			
		Compo-	TICN	(8.1)	1;CN (S. 3)	Ticn	(11.4)	Ticn	• .			TICN	(4.2)				TICN NO.	6.01			10.4	2) T	:			Tich	(6.7)			TiCN	(9.6)			T.C.	(7.6)		
	Innermost Layer	Crystal Structure	Granular		Granular	Granular		Cranular				Granular					Granular				Granular					Granular			_	Granular				Granular			
	Innerm	Compo- sition	Tin	5	T1N (0.5)	TiCN	(0.7)	Tic.	Z = 5	:		Tin	3.8				z i	2			U.F	(0.5)				TIN	60.4			N.T	= =			T.C.	(0.5)		-
	Substrate Symbol		4		۷	∢		a				8				ľ	J				L)				Q				۵				٥			
			15]:	2	-		8.				19				۶	?				7					22		_		23		_		24			
	Туре														Coated	Cemented	Cutting	Tools of	Prior Art																		

TABLE 7 (b)

. (-	natu toating Layer					Flank	Flank Wear
		Substrate Symbol	Innerm	Innermost Layer		Inner Layer	ayer	Oute	Outer Layer	Outerm	Outermost Layer	Ē	(mm)
•			Compo- sition	Crystal Structure	Compo- sition	Crystal	Orientation	Compo-	Crystal		Compo- Crystal	Continuous	1 ≕
	22	B	NIT	Granular	7.CZ	Granular	(220) (200) (111)		a: 1001		פרוחכרתום	Failure after 26.7 min.	r 26.7 min.
			16.01		(8.5)			(9.0)				due to Chipping	1 ng
Cemented	92	ώ	NiT C	Granular	7 S	Granular	(111) (200) (111)	A1203	a: 1001	Tin	Granular	Pailure after 23.3 min.	r 23.3 min.
					13.4			? :0		6.3		due to Layer Separation	Separation
Carbide	27	L.	NIT C	Granular	Tich	Granular	(111) (200) (27)	A1203	α: 1001	NI.	Granular Failure	Failure	Pailure
Tools of			9		•			÷.0)		€. €.		ofter 1.2	after 0.1
Prior Art												min. due to	min. due to
	88	o	-Nit-	Granular	TION	Granular	(111) (200) (220)	A) 203		27.6	1.0000	Chipping	Fracturing
	_		J.C.		(3.2)			672	1001:p		Granular Fallure	ratiure	Failure
			61.0					3		-		orcer 3.0	alter 0.2
												min. due to	min. due to min. due to
								_				7	

TABLE 8

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							4	0				,		,	,	
Wear	2	Inter- rupted	0.19	0.18	0.29	0.28	0.20	0.24	0.25	0.20	0.27	0.24	(Hilling)	(Milling)	0.26	0.24
Flank Wear	(ww)	Conti- nuous	0.15	0.18	0.18	0.15	0.19	0.19	0.25	0.15	0.16	0.16	0.15	0.14	0.16	0.14
	Outermost Layer	Crystal Structure	Granular		Granular	Granular		Granular	Granular					Granular	Granular	Granular
	Outermo	Compo- sition	71N (0.2)		TICN- TIN (0.8)	TEN (0.2)		TiN (0.3)	TiN (0.3)					TIN (0.2)	TiN (0.2)	TiN (0.3)
	Layer	Crystal Struc-	K:941	K: 856	K: 1006	K: 1001	K:731	K:551	K: 621	K:73	K:621	K:1004	K: 1001	K:941	K: 1001	K:941
	Outer Layer	Compo- sition	A1203	A1203	A1203 (2.1)	A1203 (1.7)	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203 (0.6)
	Pirst Intermediate Layer	Crystal Struc-	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular
ing Layer	Pi, Interm Lay	Compo- sition	71c	71C (2.4)	TIC (2.3)	TÍC (3.9)	Tic (1.0)	TIC (3.2)	TiN (1.9)	TiC (2.8)	TiCN (1.0)	TiC (2.3)	Tic (1.5)	Tic (1.6)	TiCN (1.3)	TiC (1.0)
Hard Coating Layer	yer	Orientation	(111) (220) (200)	(220) (111) (200)	(111) (220) (200)	(111) (200) (220)	(111) (220) (200)	(220) (1111) (200)	(220) (200) (111)	(111) (220) (200)	(220) (111) (200)	(111) (220) (200)	(220) (111) (200)	(1111 (220) (200)	(220) (111) (200)	(111) (220) (200)
	Inner Layer	Crystal Structure	Elongated	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated	Elongated	Elongated	Elongated Growth	Elongated Growth	Elongated	Elongated Growth	Elongated Growth	Elongated Growth
		Compo- sition	TiCN (6.5)	TiCN (3.0)	TiCN (9.3)	TiCN (4.5)	TiCN (4.9)	TiCN (6.8)	TiCN (3.3)	TiCN (3.6)	TiCN (2.6)	TiCN (5.6)	TiCN 12.51	TiCN (7.5)	TiCN (3.5)	TiCN (1.7)
	it Layer	Crystal Struc-	Granular	Granular		Granular	Granular	Granular	Granular	Granular		Granular	Granular			Granular
	Innermost Lay	Compo- sition	TiN (0.9)	TiN (0.5)		TiC- TiN (1.1)	TiN (1.6)	TiN (0.1)	TiC (0.0)	TiN (0.6)		TiCN (0.4)	TiN (0.3)			TIN- TICN (1.0)
Sub-	strate Symbol		4	<	4	83	8	c	د	q	۵	۵	ε	ŗ.	Ĺ.	v
			29	e S	3.1	32	33	34	35	36	7.	38	39	9	=	\$
	Туре						Coated	Carbide Cutting	Tools of the	Invention						

	(a)
	LE 9
	TABLE

		p c	5	a	ē		2 8	_ 3 g	2 0 0	° 3	2	23
Wear	·	Interrupted Cutting	0.54 (Chipping)	0.53 (Chipping)	0.48 (Chipping)	failure after 8.8 min. due to Layer Separation			Failure after 4.1 min. due to Fracturing	Failure after 9.2 min. due to Chipping		
Flank Wear	(ma)	Continuous Cutting	0.43 (Chipping)	0.50 (Chipping)	0.50 (Chipping)	Pailure after 11.9 min. due to Layer Separation	Failure after 11.1 min. due to Layer Separation	Pailure after 6.8 min. due to Layer Separation	Failure after 11.6 min. due to Layer Separation	Failure after 18.5 min. due to Chipping	Failure after 16.8 min. due to Chipping	Failure after 14.7 min. due to
	Outermost Layer	Crystal Struc- ture	Granular		Granular	Granular		Granular	Granular	:		
	Outern	Compo- sition	TIN (0.2)		Tich- Tin (0.6)	TÎN (0.2)		15N (0.3)	11k (0.4)			
	Outer Layer	Crystal Struc- ture	α:1001	α:1001	K: 401	α:100 1	α: 100/	α:100	K: 101	a: 1001	K: 401	α:1000
	Outer	Compo- sition	A1203	A1203	A1203	A1203	A1203 (3.9)	A1203	A1203	A1203 (4.8)	A1203 (8.1)	A1203 (7.7)
, .	Pirst Intermediate Layer	Crystal Struc- ture	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular
ng Laye	Pi Interm	compo- sition	TIC (2.5)	TIC (2.1)	71C	14.0)	11c (1.2)	T1C (2.5)	T1N (1.8)	Tic (2.9)	Ticn (1.1)	71C (2.5)
Hard Coating Layer	Layer	Orientation	(111) (200) (220)	(220) (200) (111)	(111) (200) (220)	(200) (220) (111)	(111) (200) (220)	(220) (200) (111)	(200) (220) (111)	(111) (200) (220)	(220) (200) (111)	(111) (200) (220)
	Inner Layer	Crystal Struc- ture	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular	Granular
		Compo- sition	TiCN (9.3)	11CN	TiCN (9.5)	TiCN (4.7)	Ti CN (4.8)	TiCN (5.8)	15CN (3.2)	TiCN (3.5)	TiCN (2.7)	TiCN (5.7)
	st Layer	Crystal Struc- ture	Granular	Granular		Granular	Granular	Granular	Granular	Granular		Granular
	Innermost	Compo- sition	TiN (1.0)	Tin (0.5)		TiC- TiN (1.2)	TiN (1.7)	TÎN (0.1)	TiC (0.6)	11N (0.4)		TiCN (0.5)
Sub-	strate Symbol		<	4	4	æ	, m	v	U	۵	٥	۵
			29	2	=	2	=	*	25	ž	5	86
	Туре						Coated	Carbide Cutting Tools of Prior Art				

TABLE 9 (b)

		-qns					Hard Coating Layer	ing Laye						sect doels	
Туре		strate Symbol	lnnermo	Innermost Layer		Inner Layer	Layer	Intern	First Intermediate	Outer	Outer Layer	Outerm	Outermost Layer	(444)	ê
		:	Compo- sition	Crystal Struc- ture	Compo- sition	Crystal Struc- ture	Orientation	00000 1110n	Crystel Struc-	Compo- Crystal sition Struc-	Crystal Struc-	Compo- eltion	Crystal Struc-	Continuous Cutting	Interrupted
	39	ш	TiN (0.3)	Granular	Ticn (2.5)	Granular	(220) (200) (111)	± € .	Granular	A1203	a:1001			Failure after 19.7 min. due to Chipping (Milling)	ir 19.7 min. Ing
Coated Cemented Carbide	9				TiCN (2.6)	Granular	Granular (111) (200) (220)	TIC (1.5)	Granular	A1203 (0.4)	a:1001	TIN (0.3)	Granular	Granular Pailure after 19.3 min. due CLayer Separation	r 19.3 min. Separation
Cutting Tools of Prior Art	41	in.			11CN	Granular	Granular (220) (200) (111)	TiCN (1.4)	Granular	A1203 (0.3)	α:100/	TÎN (0.3)	Granular Pallure after 1	Pailure after 1.4 min. due co	Pailure Failure after 0.1
	4 5	U	TIN- TICN (0.9)	Granular	TiCN (1.9)	Granular	Granular (111) (200) (220)	11.0 11.11	Granular	A1203	α:1001	TÍN (0.2)	Granular Pailure after 1 min. du	Chipping Pailure after 3.2 min. due to	Chipping Fracturing Palure Failure after 3.2 after 0.3 main. due to min. due to

TABLE 10

						Hard Co	Hard Coating Layer						
-												Flank Wear	Mear
ěč.		Substrate Symbol		Inner Layer	ayer	Sellntermed	Second Intermediate Layer	Oute	Outer Layer	Outerno	Outermost Layer	(mm)	=
			COMDO-	Crystal	Orientation	Compo-	Crystal	Compo-	Crystal	-OUNCO	Crystal	Continuous	Interrupted
			sition	Structure		sition	Structure	sition	Structure	sition	Structure		Cuttino
	Ç	٧	TiCN	Elongated	(111) (220) (200)	TICNO	Granular	A1203	X:941	T.F.	Granular	0.15	0.17
			(B. €)	Growth		(0.1)		(2.0)		(0.5)			
	=	4	TICN	Elongated	(220) (111) (200)	TICNO	Granular	A1203	K:851			0.16	0.17
			(5.7)	Growth		(0.1)		(6.0)					
	Ş	<	TICN	Elongaced	(111) (220) (200)	TICHO	Granular	A1203	K:1001	Tich-	Granular	0.15	0.19
			2 .E	Growth		(0.1)		6.1		Tin (0.6)			
	9.	ø	Tich	Elongated	(111) (200) (220)	TICNO	Granular	A1203	K-1004	ž	Cranular	0.14	0.20
			(8.2)	Growth		(0.1)		2.1		(0.3			
Coared	÷	ø	TICN	Elongated	(111) (220) (200)	113	Granular	A1203	K:731			0.17	0.19
Cemented			(5.0)	Growth		(0.2)		(5.3)					
Carbide	\$	υ	TiCN	Elongaced	(220) (111) (200)	1100	Granular	A1203	K: 551	712	Granular	0.18	0.21
Cutting			(10.2)	Growth		10.11		(1.2)		(0.3)			
Tools of	\$	U	TiCN	Elongated	(220) (200) (111)	TICNO	Granular	A1203	K: 621	Tin	Granular	0.22	0.23
200	1		3.4	Grouth		(0.1)		(6.0)		(0.4)			
Invention	S	٥	Tich	Elongated	(111) (220) (200)	TICNO	Granular	A1203	K: 941	TIN	Granular	0.13	0.18
			(6.5)	Growth		(0.1)		(5.4)		(0.2)			
	2	۵	11CN	Elongated	(220) (111) (200)	TICNO	Granular	A1203	K: 621			0.12	0.21
			œ 6	Growth		(0,1)		(8.2)					
	22	۵	7.C	Elongated	(111) (220) (200)	TICNO	Granular	A1203	K:1001			0.14	0.19
			5.2	Growth		(0.1)		(2.4)					
	3	ພ	T C	Elongated	(220) (111) (200)	71CNO	Granular	A1203	K:1001			0 14	(Hilling)
			3	Growth		(0.1)		(0.6)					,
	\$	ü	7	Elongated	(111) (220) (200)	Ticko	Granular	10214	K: 941	TIN	Granular	0.16	(Hilling)
			(4.0)	Crowth		(0.1)		(0.5)		(0.3)			
	ŝ	<u>.</u>	2 G	Elongated	(520) (111) (500)	21.5	Crenuler	A1203	K: 1001	Tin	Granular	0.12	0.18
	ŀ							(6.3)		6.5			
	\$	υ	£ 6.	Elongated	(1111) (220) (200)	7icko	Granular	A1203	K: 941	71.V	Granular	0.13	61.0

TABLE 11 (a)

	Flank Wear	(am)	Interrupted	Cutting	0.54	0.53	(Chipping)	0.55	(Chipping)	Failure			Layer	Separacion	after 7.8	min. due to	Layer	Separation	Failure	min due ro	Fracturing		Pailure	after 5.3	min. due to	Fracturing	Failure	ofter 11.4	min. due to	Chipping	Failure	after 8.5	min. due to	cui poi ng	after 10.1	min. due to	Chipping
	Flan	3 	Continuous	Cutcing	0.42	0.47	(Chipping)	0.43	(Chipping)	Pailure	after 17.5	min. due to	Senaration	Pailure	after 14.0	min. due to	Layer	Separation	Pailure Afres a 3	min. due to	Layer	Separation	Failure	after 13.6	min. due to	Separation	Failure	ofter 20.7	min. due to	Chipping	Foilure	_	Gin. due to	T	7	_	Chipping
		occessions tayer	Crystal	Structure	of annual ar			Granular		Granular								11.00	1000010		_		Granular				Granular						,				
			Compo-	5171ga	9			TICN-	(0.7)	TIN	6.9							3	(0.2)				21.5	<u>.</u>			Tin			1							
	Outer Laver		Crystal	Structure 5.100	1001:5	a: 1001		K: 401		Q:1001				α:100V				901.00					K: 40				a:1001		•		K: 401			a: 1001			
	Out		Compo	A170,	(2.1)	A1203	2 :	1203		1,203	6.5			A1203	(5.2)			A1201	: n			6	3 6	-			A1203	(5.5)		100	() () () () () () () () () ()			A1203	(2.3)		
Hard Coating Layer	Second	ᇵ	Structure	Granular		Granular	10000			Granular				Granular				Granular				Granular					Granular			Granular		•		Granular			
Hard C	Š	Interne	sit ion	TICNO	(0.3)	71 CNO	T CNO	10.1		0.70				0 5	3			100	2.0			TICNO	(0.1)	-			0.20	:		TICNO	1.0			ONO C			
	ayer	Orientation		(111) (200) (220)		(220) (200) (111)	(111) (200) (220)		12000112201111111	,			1000,1000,1111,	(077) (007) (177)	-			(220) (200) (111)				(200) (220) (111)				10111110001111111	1077			(220) (200) (111)		_	1111,000,1000	(0771 (007) (111)			
	Inner Layer	Crystal	Structure	Granular	1	1810181	Granular		Granular				Gradular		-			or and last				Granular				Granular			-+	Granular		_	Granular				
		Compo	sition	25	Z j.F	(5.5)	TiCN	11.5	TiCN	(8.3)			Ş	€.			20,5	500				۲ ز د خ	(2.2)			4 i CN	(6.6)			2 6			T S	(2.8)			
	Substrate			<	~		<		8								L	,	-			 U										_	۵				••
			1	=	=		\$		9				Ş	_		_	9];	<u> </u>		_		Š			1;	-		_	2		_	7	
	Туре										_					Cemented	Carbide	Cutting	Tools of	Prior Art																	

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						Herd C	Hard Coating Layer						
-Type		Substrate Symbol		Inner Layer	, ayer	10. eme	Second	Ore	Outer Layer	Outerm	Outermost Layer	Flank W	Flank Wear (mm)
			Compo-	Crystal	Orientation	Compo	Crystal	Compo	Crystal	Compo	Crystal	Continuous Interrupted	Interrupted
	S	3	F.C.	Granular	(220) (200) (1) 1)		TICHO SCRUCTURE SICION	\$1C10n	Structure sition	Sition	Structure	Structure. Cutting	Cutcing
			(4.2)				Granular	A120	a: 1001			Pailure after 26.9 min.	r 26.9 min.
1	ŀ											due to Chipping	ğe j
Cemented	ň		2015	Granular	Granular (111) (200) (220)	TICNO	Granular	A1203	g. 1004	Tin	Granular	Granular Pailure streets	
40.47.47			5			 		9	-	ŕ			. 44.4 min.
200	Ŀ							:				due to Layer Separation	Separation
Cor 1 mg	<u>`</u>	L .	TI CN	Granular	(220) (200) (111)	7100	Granilar	Š					
1001			14.5				_	52.5	a: 1004	MIT.	Granular Failure		Failure
Prior Art								(c. o)		÷.		after 2.0	ofter 0.2
												min. due to min. due to	min. due to
	26	ن	TiCN	Granular	100011000111111	91.010						Chipping	Fracturing
			13.23		10221 (0021 1	200	oranu18r	A1203	a: 1001	Į,	Granular Failure	Failure	Failure
	_					:		(8.0)		(0.2)		after 5.2	after 0.7
												min. due to	min. due to min. due to

TABLE 11 (b)

TABLE 12

						_			т	_			~~	~			_								,		
	Flank Wear	(mm)		Inter-	Cutting	0.14	61.0		0.15		0.16		0.17		<u></u>	0.21		0.15	6.13		\$	ופטווויאו	100111111		0.16	3	-
	Flan	=		Cont i -	Cutting	0.0	0.15		0.14		0.13		0.16			0.20		0.12	0.11		2	0.12	0.14		0.11	2	
		Outermost Layer		Crystal Structure		Granular			Granular		Granular			Granular		Granular		Granular					Granular		Granular	Granular	
		Outerno		Compo- sition		z í			TICN- TIN	Ē	(0.3)			T.Y.	(0.3)	Z	(2)	N ()					zit	10.31	2 6	Zir	10.21
		Outer Layer		Struc-	ture	K:94	K: 851		K:1001		K:1001		K:73	K; 554		K: 621		K: 94	K: 621	r . 1004		K:1001	K: 941		K: 1001	K: 941	
		Outer		sition	+	<u> </u>	Ļ	9	A1203	3	(2.0)	,	*1203	A1203	11.11	A1203	2 5	2 5	A1203	A1203	12.51	A1203	A1203	9	1203	1,20,	(0.8)
		Second Intermediate	Layer	Struc-	ture		Granular		Granular	Granular		1.00.5	18101810	Granular		Granular	Granular		Granular	Granular		Granular	Granular		or and tar	Granular	
Hard Coating Layer		Inter	1	sition	P.CNO	0.1	Ticho		(0.1)	TICHO	(0.1)	1,00	(0.2)	1100	9	71CNO	TICHO	(0.1)	TICNO	TICNO	10.11	(0.1)	Ticno	2 2	9.7	TICNO	10.21
Hard Coa		ayer ayer	Orientation		(111) (220) (200)		(220) (111) (200)	100011000111111	(007) (077) (111)	(111) (200) (220)		(111) (220) (200)		(220) (111) (200)		(111) (200) (111)	(111) (220) (200)		(220) (111) (200)	(111) (220) (200)	19301 (1111) (000)	(007) (111) (077)	(111) (220) (200)	(220) (111) (200)		(111) (220) (200)	
	20001		Crystal	<u>~</u> _	Elongaced	Growth	Elongar ed Growth	Elongared	Growth	Elongated	Growth	Elongered	Growth	Elongated	F) Once to d	Growth	Elongated	Growth	Elongated Growth	Elongated	Floorared	Crowth	Elongated	Elongated	Growth	Elongated	
			Compo-	sition	F.C.	(B. 5)	7iCN (5.6)	TiCN	(11.5)	TICN	(8.2)	TiCN	6.9	71CV	2	(5.3)	TICN	(6.4)	71CN (3.8)	TiCN	, L	2 2	2 G 5	TICS	(4.6)	N C	
	Innermost Laver		_	Struc. ture	Granular		Granular	Granular		Granular		Granular		Granular	Granular		Granular		cranular	Granular	Granular		Granular	Granular		Granular	
	Innerm		Сошро-	sition	Z.F	6	6.5 S.S.	TICN	(0.8)	Tic.	(1.4)	ViT	9 :	2 i	Tic	(0.5)	z i	60.01	(1.2)	TiCN (0.4)	TiN	10.31	(0.3)	N.T	(, 0)	TiCk	1.0
-qng	Strate	Symbo1			٧		٠	~		a		æ	,	J	J		۵	6	,	۵	3			4	,	٠.	
					53	19	۶	23	[:	9	Ī	61	1	7	3	Ţ	3	15	;	99	150	:	;	69	۶	?	
	Type							-			1	Coated	Carbide	Cutting	Tools of		no t no t	_1_	1		1	L					
													_				_										

		lear.		Interrupted	Cutting	5	(Chipping)	0.49	(Suitpping)	(Chipping)	Failure	ofter 12.3	min. due to	Separation	Failure	after 8.6	min. due to	Separation	Failure	ofter 1.7	min. due to	Practuring	Failure	after 5.9	min. due to	Fracturing	Sei lus	after 12)	min. due to	Chipping	Failure	ofter 9.3	min. due to	Failure	after 10.8
		Flank Wear (mm)		5	Cutting	0.38	(Chipping)	0.41 (Chipping)	0.40	(Chipping)	Pailure		min. due to m	tion	T		lue co	Separation S	1	_	os an	Separation	╁╴	9.	tue co		Failure	-	3]		S	Min. due to mi	+	- S
		Outermost Layer		Crystal	ture	Granular			Granular		Granular								Granular	_			Granular						.		_		<u> </u>		. E
		Outern		Compo-	sition	Tin	60.5		TICN-	TIN (0.6)	Tir	9.5							T.N	(c. 5)			T.	(9.6)											
		Outer Layer	ŀ	Crysta	_	α: 100 1		a: 1001	K:400		a: 1004	•			Q: 1001		,		Q: 1001				K: 404				a: 1004				K: 40		i	a: 1001	
		Outer		Compo		A1203	-	(5.9)	<u> </u>	(1.7)		(2.2)			A1203	(5.0)			41203	(8.0)			A1203	1.0			A1203	(5.3)		67.14		(8.2)		A1203	(2.5) _
_	<u></u>	Second	Layer	Crystal Struc-	ture	Granular	Gradu		Granular		Granular				Granular				Granular				Granular				Granular			Granular				Granular	
13 (a)	ing Laye	Incer		Compo	8118	TICNO	1 2	(0.1)	TICNO	17.01	T1CN0				12.00			3	9 7					:			TICNO	-		TICNO	_		_	1 C C C	
TABLE	Hard Coating Layer	Layer		OLIENCACION		(111) (200) (220)	(220) (200) (111)		(111) (200) (220)		(111)			(000) (111)	10771 (0071 (1111			127011005110551	(111) (007) (0**)			1,1000,1000,1000,					(111) (200) (220)			(220) (200) (111)			-	(111) (200) (220)	
		Inner Layer	Crystal	Struc-	ture	Granular	Granular		Granular		18101810			Granular			_	Granular				Granular				_	cranciar			Granular				- Leanniar	
			Compo	sition		TiCN (8.4)	TICN	(5.3)	(11.3)	2016	(8.1)			Tics	(4.8)			TiCN	(10.2)			FICN	(5.4)			100	(9.9)			Tick	6.6		Z E	1.0	
		ost Layer	Crystal	Struc-	ture	Granular	Granular		1810181	Granular				Granular				Granular				Granular				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				Granular			Granular		<u> </u>
		Innermost		sition		ž 5.	Tin	9 5	(0.7)	-110-	Tin	(1.5)		7 in	11.63			Tin	0.13			Tic	÷.			N.F	(0.5)	-		zi.			┰	(0.5)	
	-qns	Symbol				∢	4	-	:	63								U		_		U				٥			1	<u> </u>			-		
		8				57	88	S		9				61		_	_	62				G			_	3			ŀ	ç		_	\$		
		 هرکر	_												Posto	Cemented	Carbide	Cutting	Tools of	:			-												

TABLE 13 (b)

TABLE 14

	Sub-					Hard Coating Layer	ing Layer							
2													Flank	Flank Wear
<u>.</u>	9 C C C C C C C C C C C C C C C C C C C		Inner Layer	ayer	Ĭ	First	Sec	Second	Outer Layer	Layer	Outerm	Outermost Layer	(em)	
	ogwice -				Interi	Intermediate	Interm	Intermediate						:
		3	٠.		3		-	rayer						
		sit ion	Crystal	Orientation	-odwo	Crystal		Crystal	Compo-	Crystal	Compo-	Crystal	Cont i -	Inter.
			_		\$1010u	scree.	#1C10U	Struc-	sition	Struc-	sition	Structure	Snonu	rupted
1,	١ ٧	TiCN	Elongared	(111) (220) (200)	٤	Green, les	CAO JE			ain			Cutting	Cutting
		(6.3)	Growth		0.3		10.13	or anutar	1203	K: 941	2 7 0	Granular	9.16	0.20
72	۷ ۲	TiCN	Elongated	(220) (111) (220)	TIC	Granular	TICNO	Granuler	V1203	K:851			0.19	67.0
_1:	1		Crowen		G 2		(0.1)		(6.9)					
	۲ د د	ž ć	Elongated	(1111) (220) (200)	TIC	Granular	TICHO	Granular	1120	K: 1001	Tick-	Granular	0.16	0.21
		, ,	20020		3.0		60.1		(2.1)		z f			
_	74 8	4ion	Elongated	(111) (200) (220)	Tic	Granular	SE SE	Granular	1					
	_	(4.6)	Growth		3.8		0.1)			100 1	(O.)	cranular	0.15	0.23
_	75 B	11CN	Elongated	(1111) (220) (1111)	715	Granular	1100	Granular	6	1			,	;
L		<u>=</u>	Growth		(3.4)		(0.1)		(a	17.2			5	0.21
Carbide	ر د	1.0v	ei ei	(220) (111) (200)	TIC	Granular	1100	Granular	12	1	2 F	Section 1	9	
	1	(6.6)	-4		(3.1)		(0.3)			100:4	9		3	77.0
T0015 of 7	٠ <u>۲</u>	TiCN	<u></u>	(1111) (200) (022)	Tin	Granular	TICHO	Granular	۸ ور ۲	5	3 7	Granular	,	1
		ŝ	Growth		(1.9)		(0.1)			70:4	(0.5)	191916	5	\$7.0
Invention 7	78 D	£ 5	Elongated	(1111) (220) (200)	TIC	Granular	TICHO	Oranular	A1203	K: 73	11N	Granular	0.15	0.19
Ľ	,		4		(,,,)		(0.1)		15.21		(0.5)			
	<u> </u>	2.5	Growth	(220) (111) (200)	2 3 F S	Granular	TICNO	Granular	41203	K: 621			0.14	0.22
1=	90 P	TiCN	Elongarad	100611066111111	,				9					
		(5.5)			(2.6)	101010	1100	Granular	A1203	K: 1001			0.15	0.21
- 81	ы 	Ti Cr	ӹ	(220) (111) (222)	110	Granular	TICNO	Granular	9	3			1	
_1		3.5	Srowth		(1.3)		6.13		9	001:4			- -	HILLING!
82		7 C	Elonyated	(111) (220) (200)	Tic	Granular	TICNO	Cranular	1,20,1	K: 941	ZIN	Granulur	0.17	(M.111ng)
[6	١		4		?		=		9		(0.2)			
•]		(3.4)	Growth	(220) (1111) (200)	11CN	Grenuler	7iC9	Granular	A1203	K: 1001	N. C	Granular	9.14	0.20
*	<i>5</i>	TICN	Elongaced	(111) (220) (200)	71.0	Granular	TICNO	Granular						
		2.5	Growth		(0.1)		(0.2)	•		¥: 34:	(0.3)	cranutar	6.5	0.19

TABLE 15 (a)

		Sub.					Hard Coating Layer	ng Laye							
λype		Strate		Inner Lover	Laver	ľ								Flank Wear	Wear
		Symbol			;	Inte	Intermediate	Inter	Second	Outer Layer	Layer	Outern	Outermost Layer	(100)	ā
			Compo	Crystal	20,100,00	-	Layer	3	Layer						
			sition	Struc-	not server to	Compo-	Crystal Struc-	od i	Crystal Struc-	Compo- sition	Crysta	Compo.	Crystal Srruc-	Continuous	Interrupted
	-			ture			ture		ture		Struc-	eicion eicion	ture	5011300	Cutting
		<	T1CN (6.2)	Granular	(111) (200) (220)	T1C (3.2)	Granular	T1CNO (0.1)	Granular	A1203	a: 1001	Tin	Granular	0.43	0.53
	72	۷.	TiCN (3.0)	Granular	(220) (200) (111)	T1C (2.0)	Granular	TICNO	Granular	A1203	a: 1004	6.5		(Chipping) 0.49	(Chipping) 0.52
	ι,	٧	TiCN (9.3)	Granular	(1111) (200) (220)	Tic (2.1)	Granular	TICNO (0.1)	Granuler	A1203	K: 408	TICN-	Granuler	(Chipping)	(Chipping) 0.40
	7		J.C.	Granular	1111111000110001							(9.0)	-		(Curbbrud)
			5.5		(111) (022) (002)	(3.7)	Granular	71CN (0.1)	Granular	A1203	a: 1001	TIN (0.2)	Granular	Failure after 14.7	Pailure after 9 5
									···					min. due to Layer	min. due to Layer
	75		73.5	Granular	(111) (2001 (220)	5								Separation	Separation
Coated			(4 .8)			2	18101810	0.1.	Granular	A1203	a: 1001			Failure Afrer 12 1	Failure
Cemented	_													min. due to	min. due to
Carbide	1;	1												Layer	Layer
Tools of	9	u	Z :	Granular	(220) (200) (111)	TIC	Granular	418	Granular	6,14	180	72.7		Separation	Separation
Prior Art			<u>.</u>	_	-	(5.9)		(0.2)		1.2		60.43		after 6.8	Failure after 1.2
														min. due to	min. due co
	15	1.	2 F	7.1				_						Layer Separation	Practuring
	_	,	, ?		(1111) (077) (007)	Z ·	Granular		Granuler	A1203	r. 401	ž	Granular	East lives	
						= = :		2. 0.		(0.8)		5.0		#fter 11.9	efter 4 4
											•			lue co	min. due to
	18,	ľ	_	Cranilar	.020, 000, 1111			-						Separation	Fracturing
			3.5		10221 10021 1111	710	Granular	710%	Granular	A1203	a: 1001	T'S	Granular	Failure	Failure
						:				(5.1)				-	after 9.5
	۶	6	\top											min. due to	min due to
	:	,	2.4	or and tar	(1111) (2007) (077)	7 i c	Granular		Granular	A1203	K: 401			\dagger	Failure
						3		- - - -		(8.1)			,		after 6.8
	1:		_											3	min, due to
	 B	٥	Š	Granular	(111) (200) (220)	Tic	Granular	TICNO	Granular	ć		1	1	1	Chipping
			S		-	(2.5)	_	_		6 6	1001:2			Failure	Failure
	┪		-										<u> </u>	_	min. due to
														_	chipping

		Sub-					Hard Coating Layer	ng Laye							
Jy pe		strate Symbol		Inner Layer	Layer	Inter	First Intermediate	Se	Second Intermediate	Outer Layer	Layer	Outerm	Outermost Layer	rionk wear (mm)	a)
			Compo- sition	Crystel Struc- ture	Orientation	Compo-	Crystal Struc- ture	S S S S S S S S S S S S S S S S S S S	Crystal Struc-	Compo- Crysta sition 1 Struc-	Crysta 1 Struc-	Compo-	Crystal Struc- ture	Continuous Interrupted Cutting Cutting	Interrupted
	ã	2	TiCN (2.4)	Granular	Granular (220) (200) (111)	7ic (1.5)	Granular TiCNO Granular (0.1)	Ticho (0.1)	Granular	A1203 (0.4)	α: 100%			Pailure after 23.2 min. due to Chipping	r 23.2 min. ing
Coated Cemented Carbide	82	.3	TiCN (2.5)	Granular	Granular (111) (200) (220)	Tic (1.4)	Granular TiCNO Granular (0.1)	Ticno (0.1)	Granuler	A1203	a: 1004	TiN (0.2)	Granular	Granular Fallure after 20.1 min. due to Layer Separation	r 20.1 min. Separation
Cutting Tools of Prior Art	63	ů.	TÍCN (3.3)	Granular	Granular (220) (200) (111)	T1CN (1.3)	Granuler	1,00 (0.1)	Granular	A1203	a:1001	TÍN (0.2)	Granular Failure after 1. min. due	Fallure Failure after 1.6 after 0.1	Failure after 0.1 min. due to
	2	ن ن	TiCN (1.8)	Granular	Granular (111) (200) (220)	7ic (1.0)	Granular TiCNO Granular (0.2)	TICNO (0.2)	Granular	A1203 (0.7)	a: 1001	11.0 10.31	Granular Failure after 1 min. due	Failure Failure after 0.) Annual of the control of	Facturing Failure after 0.3 min. due to

TABLE 15 (b)

TABLE 16

		8	T										2	=	T	
Plank Wear	(mm)	Interrupted	0.19	0.18	0.20	0.22	0.19	0.23	0.24	0.19	0.21	0 20	(4,11,09)	(H1111ng)	0.19	0.18
Plan	_	Continuous Cutting	0.15	0.17	0.15	0.14	0.18	0.18	0.23	0.13	0 (1.0	0.14	0.14	0.16	0.13	0.13
	Outermost Layer	Crystal Struc-	Granular		Granular	Granuler		Granular	Granuler					Granuler	Granular	Granular
	OUE	Compo- eltion	TIN (0.2)		TICN- TIN (0.6)	4ik (0.2)		3 F 0	11x					† 10.0	4 (C. 0)	Tin (0.2)
	Outer Layer	Crystal Struc-	K:941	K:851	K: 1004	K: 1001	K:731	K:551	K:621	K:731	K:621	K: 1001	K: 1001	K:941	K:1001	K:941
	Outer	Compo- sition	A1203	A1203	A1203 (2.0)	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A120,	A1203	A1203
	Second Intermediate Layer	Crystal Struc-	Granular	Oranular	Granular	Granular	Granular	Granuler	Granuler	Granuler	Granuler	Granular	Granular	Granular	Granuler	Granular
	Sec	Compo- eltion	71CNO	TiCNO (0.1)	T1CNO (0.1)	71CNO (0.1)	T1C0	1100	T1CNO (0.1)	71CNO	TICNO (0.1)	TICNO (0.1)	TiCNO (0.1)	TiCNO (0.1)	7iC0 (0.1)	T1CNO (0.2)
Hard Coating Layer	First Intermediate Layer	Crystal Struc- ture	Granular	Granular	Gramler	Granuler	Granular	Gramlar	Granuler	Granular	Granular	Granular	Granular	Granular	Granular	Granular
ard Coat	Inter	Compo- strion	11C 0.0	Tic (2.3)	TiC (2.1)	Tic (3.8)	Tic (1.2)	71C (3.0)	TiN (1.1)	T1C (2.8)	71CM	7iC (2.5)	Tic (1.4)	Tic (1.5)	TiCN (1.4)	T1C (1.0)
x	yer	Orientation	(111) (220) (260)	(220) (1111) (200)	(1111) (220) (100)	(111) (200) (110)	(1111) (220) (200)	(330) (111) (300)	(220) (200) (111)	(111) (220) (200)	(230) (111) (200)	(111) (2201 (2001	(320) (1111) (202)	(111) (220) (200)	(220) (111) (200)	(111) (220) (111)
	Inner Layer	Crystal Structure	Elongated Growth	Elonget ed Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Orowth	Elongated Growth	Elongated	Elongated Growth	Elongeted Growth	Elongated	Elongated Growth	Elongated Growth	Elongated Growth
		Compo- eltian	TiCN (6.4)	TiCN (3.0)	Ticn (9.2)	TiCN (4.7)	TiCN (4.8)	TiCN (6.7)	TiCN (3.2)	TiCN (3.6)	TiCN (2.3)	TiCN (5.4)	T1CN (2.6)	TiCN (2.5)	TiCN (3.2)	TiCN (1.9)
	Innermost Layer	Crystal Struc- ture	Granular	Granular	Granular	Granular	Granular	Gramlar	Grenuler	Granular	Grenular	Granuler	Granular	Granutar	Granular	Granular
	Inne La	Compo- eition	Tin (0.8)	TiN (0.4)	TiCN (0.7)	TiC- TiN (1.2)	TiN (1.5)	TiN (0.1)	TiC (0.7)	TiN (0.6)	TiN (1.0)	TiCN (0.4)	TiN (0.3)	TiN (0.3)	TiN (0.5)	TiN- TiCN
ġ	Symbol		٧	4	۷ .	8	es.	U	U	۵	٥	Q	E	ü	ís.	C
			8 2	9,6	87	88	68	ç	16	35	93	94	\$	96	26	98
	Туре						Cemented	Cutting	Tools of							

		_			Τ	1		Γ.	T	т-:-	Т.	1	T .	1	Τ.	Τ-	Τ.	T .
5		Flank Wear	Ĩ	Interrupted Cut and	0.52 (Chipping)	0.50 (Chapeane)	0.39 (Chipping)	Parlure Layer		Pailure affer 1 5 als de co	Pallura ales de co	10 mm			failure after 33 3 ain	Lipototion	fellure effer 0 i	1,7,1,1,1
3		Flenk		Coat inwous Cutting	0.41 (Chipping)	0.48 (Chipping)	0.35 (Chipping)	Figure 15.1		Parties 2.1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Felluce etter 19.3 nin. due to	fellure ofter 13 6 als due to	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	failure ofte	fellure after 20 7 min	Failure efter 1.8	2. To 1. To
10			Dutermost	Crystal Rever	Orangler		Granular	Gramler		Gramulor	Orașuler					1	Cramilar	Granular
			§ 2	j 1	TIN (0.2)		를 보고 (c. 6)	11.0 (6.2)		11.0 (6.3)	416 (0.4)					¥ ?	¥ .	3
			, kg	Crystal Rose:	a: 1001	a: 1004	K: 404	a: 100¢	a: 100%	a: 1001	K: 406	a: 1001	K: 404	a: 1001	a: 1001	a. 1001	a. 1001	0:1001
15			2	11.00	1203	A1203	A1203 (2.2)	A1203	Al203	41203	A1203 (0.9)	A1203	A1203	A1203	1303	10,00	10.41	19.03
	_		Second Intermediate Layer	Crystal Reserv	Granular	Oramiar	Orientas	Oramular	Oramiar	Granular	Organise	Granuler	Granulas	Granuler	Gramlar	Cramise	Crambar	Grabular
20	TABLE 17	ı	3 2 3	j !	TICNO (6.1)	1100	Ticko (0.1)	T1CNO (0.1)	71C0	71C0	TICNO (0.1)	TICNO (0.1)	TICNO (0.1)	11CNO 18.11	11 CE 10 . L	11CN 10.13	5.5 1.0	T1CNO 10.23
	TAB	Hard Coating Layer	First Intermediate Layer	Crystal Struc: ture	Oramiar	Granular	Granular	Granulae	Oramiae	Granular	Oranulac	Granular	Granular	Gearules	Granuler	Granular	Granules	Granuler
25		ard Coa	2 3 3	<u> </u>	7.C C.C	71C 2.9	TIC (2.2)	Tic (3.9)	7(C.1)	71C (3.0)	TIN (1.8)	TIC (2.9)	TiCN (1.3)	71C (3.4)	71C	TIC 11.51	NOT.	2 T
		*	Layer	Or 14116 1 100	111111200112301	1330) (300) (1111)	111111300113301	(300) (330) (311)	111111200112301	(220)(200)(1111)	(2001/2301/1111	111111340113301	127011266111111	111111286112361	122011288111111	111111300113301	122011200111111	111111280113281
30			Inner L	Crystel Medic Luce	Cranular	Cranular	Granular	Granulor	Granular	Granulae	Cranular	Granuler	Granular	Granular	Granuler	Granuler	Grantae	Granuler
				Compo.	1.0.4 16.0	1,CN	T1CN	T1CN (4.6)	71CN (4.7)	TICN 16.5)	TiCN (1.1)	T1CH (3.4)	T.CN (2.5)	71CN 15.51	T1CN (2.5)	T1CN	T1CN (1.1)	T1CN
35			Innermust Layer	Caystal Struc.	Granular	Granules	Gramiae	Granuler	Cranular	Granuter	Granuler	Granular	Co anulas	Granular	Granules	Granular	Cranular	Cranulor
			7	10.00	TiN (0.9)	T1N 10.43	T1CN (0.5)	TiC. Tin	TIN (1.6)	T[N (0.1)	TiC (0.0)	TIN (0.5)	71N (0.9)	TiCN 19.5)	10.0 0.0	1.00 1.00	T1N (0.4)	T1K- 71CN 11.01
40	4	į	S S S S S S S S S S S S S S S S S S S		<	٧	٧	8		υ	υ	0	0	٥	u	ن	4	ن
					\$	16	87	œ,	83	9.0	<u>.</u>	3.5	3	ž	4.5	*	6	9.6
			ያ የ						Conted	Carbide Cutting Tools of	Prior Art							
46																		

TABLE 18 (a)

		Forth Divided Layer	Compo- Crystal aition Structure	TiCN Elongaced	+-											TiCN Elongated	Crock
		Third Dividing	10 · 0 · 0	ular.		-										Granular	
		Fird 2	Compo- sition	TiN (0.2)											-	TiN (0.2)	
		Third Divided Layer	Crystal Structure	Elongated				Elongated		Elongated	l Year	Elongated	Flongsted			Elongated	
		Third Di	Compo-	71CN				TICN (2.6)		TiCN (2.8)		TiCN (1.0)	TiCN (2.4)			TiCN (1.9)	
/er	Inner Layer	Second Dividing	Crystal Struc- ture	Granular				Granular		Granular		Granular	Granutar			Granular	
ing La	In	Second	Compo- sition	TIN (0.2)				TÍN (0.2)		Tin (0.2)		TiN (0.2)	TiN (0.2)			Tin (0.2)	
Hard Coating Layer		Second Divided Layer	Crystal Structure	Flongated	Slongated	Elongated Growth	Elongated	Elongated	Elongated Growth	Elongated	Elongated	Elongated	Elongated	Llongated	Elongeted	Elongated	Elongated Growth
		Secon	Compo- sition	4.C	71CN (3.0)	7iC 3.1	71CN	7.CN	TiCN (2.3)	TICN (2.6)	TICN (4.8)	7.iCN (0.8)	4iC.	TiCN (3.2)	TiCN (1.0)	TiCN (1.8)	TicN (3.5)
		Firet Dividing Layer	Crystal Struc- ture	Granular	Granular	Granuler	Granular	Granular	Granular	Granular	Granular	Granular	Granuler	Granular	Granuler	Granular	Granuler
		7179	Compo- eltion	TiN (0.3)	TiN (0.2)	TiN (0.2)	TiN (0.2)	TiN (0.2)	TiN (0.3)	TiN (0.2)	TiN (0.2)	rin (0.1)	TiN (0.3)	7,1 (0.3)	TiN (0.2)	TiN (0.3)	TiN (0.2)
		First Divided Layer	Crystel Structure	Elongated Growth	Elongat ed Growth	Elongated	Elongated	Elongat ed Growth	Elongated Growth	Elongated	Elongated Growth	Elongated	Elongeted	Elongat ed Growth	Elongat ed Growth	Elongat ed Growth	Elonget ed Growth
		First Di	Compo- sition	TICN	TiCN (3.0)	TiCN (3.2)	TiCN (3.1)	TiCN (7.7)	TiCN (2.2)	TiCN	TiCN (4.7)	TiCN (1.1)	7iCN (2.5)	T1CN (3.2)	TiCN (1.2)	TiCN (2.0)	TiCN (3.4)
	Innermost Layer		Crystel Struc- ture	Granuler		Granular	Granular		Granular	Granular		Geanulae	Gramuler	Granular	Granular	Granular	•
	Inne		Compo- sition	1 in		TiN (0.5)	TiN (0.5)		TiC- TiN (1.4)	TiN (1.6)		Tic (0.5)	T1N (0.5)	TiN (0.6)	TiN (0.8)	TiCN (0.6)	
ġ	strate Symbol			۷.	4	٧	4	6	æ.	gs.	U	U	U	O	۵	۵	O
				6	001	101	103	101	104	105	106	10.1	•	109	110	Ξ.	112
	Type Coated Carbide Cutilds Cutilds																

TABLE 18 (b)

	Plank Wear	Outernost (mm)	Layer	al Compo- Crystal High-feed Deep-cut	TIN (0.2)	00 TiN Granular 0.16 0.20 (0.2)	11CN- Granuler 0.17 0.18 (0.6)		0.16 0.22	14 TiN Granular 0.15 0.17	0.20 0.16	54 TIN Gramler 0.20 0.21	0.24 0.20	(1 TiN Granular 0.19 0.23	71 0 0.15 0 17	21 0.15 0.22	0.16 0.19	Nit.
	<u>u</u>	Outer Layer	•	Compo- Crystal	A1203 K:948	A1203 K: 1000	A1203 K: 1000	A1203 K:734	A1203 K; 1008	A1203 K:734	A1203 K:558	A1203 K: 851	A) 203 K: 621	A1203 K:944	A120) K:73N	A1203 K: 62N	A1203 K: 1001	A1201 K. 718
	Hard Coating Layer	Second	Intermediate Layer	Crystal Struc-	rel o	Gramlar			Granular	Granular	Cranular	Granular	Grenuler		Granular			
	Hard	S	Inter	Compo- eition	71CNO	71CNO			71CO	TiCNO (0.1)	71C0	71C0	T1CN0 (0.1)		71CNO (0.1)			
		First Intermediate	Layer	Crystal Struc- ture		Granuler	Granuler	Granular		Granular			Granuler			Granular		Tic
		Fi Inter	2	Compo- sitlon		1ic	11C	11C		TiC (3.8)			TiN (1.8)			TiCN (1.4)		Tic
		Inner Layer		Orientation	11111 (320) (300)	(320) (1111) (300)	(111) (220) (200)	(1111) (2001) (1111)	(111) (220) (200)	(111) (200) (220)	(1111) (220) (200)	(220) (111) (300)	(1111) (002) (022)	(002) (022) (111)	(1111) (230) (300)	(320) (111) (320)	(1111) (230) (300)	
		strate Symbol			<	4	<	<	80	æ	æ	U	U	U	٥	٥	٥	۵
l					66	001	101	102	61	ō	\$01	106	107	801	30t	110	=	=
		Jype 1							Coated	Carbide Cutting Tools of	the Invention							-

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TABLE 19 (a)

Hard Coating Layer	Inner Layer	Second Dividing Third Divided Layer Third Dividing Forth Divided Layer Layer	Compo- Crystal Compo: Crystal Compo- Crystal Compo- Crystal altion Structure altion Structure sition Structure ture	TiCN tlangated		(0.3) Granular (1.9) Grooth Grooth		(0.1) Granular (1.0) Etongated Growth		(0.2) Granular 71CN Elempated (1.0) Grack			(0.2) Granular (0.6) Elongated (0.2) Granular TiCH Elongated Grooth				
Hard		Second Divided Layer	- Crystal ftructure	(Crowth		N Blongated Growth	N Clongated Growth	<u> </u>	N Elongated Growth	-	<u> </u>	N Elongated	S) Elongated Growth	-	*	N Elongated 3) Growth	-
		3	Compo- etrion	71CN (1.5)	71.0x	TICN (2.0)	TiCN (2.3)	71CN	71CN	11CN (0.8)	71CN	TiCN (2.0)	T1CN (0.6)	11.39	TiCN (1.1)	71CN (1.3)	71CN (1.6)
! !		First Dividing Layer	Crystel Struc- ture	Granular	Granular	Granuler	Granular	Granular	Granular	Granular	Granuler	Grenuler	Granular	Granuler	Granular	Granuler	Granular
		Pirot	Compo- altion	TIN (0.2)	TiN (0.1)	TiN (0.2)	TiN (0.3)	Tin (0.2)	TIN (0.2)	TIN (0.1)	TiN (0.2)	TIN (0.2)	Tin (0.2)	TiN (0.1)	TiN (0.1)	TiN (0.3)	TÎN (0.2)
		First Devided Layer	Crystal Structure	Elongat ad Growth	Elangated Growth	Elongated Growth	Elongat ed Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongated Growth	Elongat ed Growth	Elongated
		First Dev	Compo- eltion	TiCN (1.6)	TiCN (0.9)	TiCN (1.9)	TiCN (2.2)	TiCN (1.1)	TiCN (3.4)	TiCN (1.1)	TiCN (1.7)	TiCN (2.2)	TiCN (0.7)	Ticn (1.3)	TiCN (1.8)	TiCN (1.4)	TiCN (1.5)
	Innermost Layer		Crystel Struc- ture	Granuler	Granular			Granular		Granuler			Granuler	Grenuler	Cranular		Granular
	Inne		Compo- sition	TiN (0.4)	TiN- TiCN			TiC- TiN (0.9)		Tin (0.5)			TiCN (0.6)	TiN (0.3)	TiN (0.3)		TiC (7.0)
-d.S.	Sympol			la.	ĹL.	is.		υ	υ	ပ	U	U	ш	3	u	ü	ü
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	17pe							Costed	Carbide Cutting Tools of	the Invention							

TABLE 19 (b)

Plank Wear	(max)		Interrupted Cutting	0.18	0.19	0.25	0.21	0.20	0.24	0.20	0.19	0.23	(Hilling)	(Milling)	(Hilling)	(Hilling)	0.14 (Hilling)
Plank	5		Cont Innous Cutting	0.14	0.12	0.13	0.14	0.12	0.11	0.15	0.14	0.12	0.14	0.15	0.14	0.15 (1	0.14
		Layer	Crystal Struc-	Granular	Granular		Granular		Granular	Granuler			Granular		Granular		Gramler
		3	Compo- sition	TIN (0.2)	TIN (0.2)		71k (0.0)		TÎN (0.4)	TIN (0.5)			5 (C. O)		11N (0.2)		TIN C
			Crystal	K: 1004	K: 941	K: 1001	K: 941	K:551	K:941	K: 624	K:851	K: 1004	K:941	K: 1001	K: 1001	K: 1001	K:94
ayer	1		Compo- sition	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203	A1203
Hard Coating Layer	puod	Intermediate	Crystal Struc-	Granuler	Granular			Granular	Granular		Granular			Granular	Granuler		Gramler
Rard	3	Inter	Compo- sition	71C0	TiCNO (0.2)			71C0	TiCO (0.1)		7iCNO (0.1)			#1CNO (0.1)	T1CNO (0.1)		TiCNO (0.2)
	Firet	Intermediate Layer	Crystel Struc-	Granular		Granular				Granular	Granular			Granuler		Granular	
	4	Inter	Compo- sition	41.C		11CN				TÍN (1.1)	T1C (2.9)			Tic (1.4)		TiCN (0.8)	
	Inner Laver		Ortantation	(220) (111) (200)	(111) (220) (200)	(1111) (220) (200)	(1111) (2001 (220)	(111) (220) (200)	(220) (111) (200)	(220) (200) (111)	(1111) (1210) (1200)	(320) (111) (300)	(111) (230) (300)	(330) (111) (300)	111111230113001	(320) (111) (300)	(002) (022) (111)
å	Symbol			ů.	٦		۵.	U	U	9	o .	U	υ U	E	3	Ε.	.3
				Ē.	114	<u> </u>	116	113	::	6 11	130	Ē	Ē	<u> </u>	• • • •	ŝ	126
	Type					•		Coated	Cutting Tools of	the Invention							*

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TABLE 20

		T		$\overline{}$		_	$\overline{}$		T	·				7		
Wear	2		0.53 (Chipping)	0.52 (Chipping)	0.43 (Chipping)	0.57 (Chipping)	0.60 (Chipping)	0.39 (Chipping)	Failure after 21.6 mm. dus to Layer	Failure after 20.8 min. due to Layer	Failure after 9.8 min. due to layer	Fallure after 20.8 min. due to Layer	0.54 (Chipping)	Feilure efter 3.6 min. due	Fallure after 5.9 min. due	Fallure after 6.5 mln. due
Flank Wear	(mm)		0.57 (Chippang)	0.61 (Chipping)	0.59 (Chipping)	0.60 (Chipping)	0.64 (Chipping)	0.59 (Chipping)	Failure after 21.6 min. due to Layer	Failure after 19.5 min. due to Layer	Feilure after 15.1 min. due to Layer	Fellure after 19.5 min. due to Layer	0.59	Failure after 13.9 min. due	Failure after	Fallure after
	Outermost Layer	Crystal Struc-	Grenuler	Granular	Granular	Granular		Granuler	_	Granu) ar		Granular				Cranular
	Oute	Compo- sition	4 (S. 2)	TiN (0.2)	TiCN- TiN	TÍN (0.3)		TÍN (0.3)		TÎN (0.2)		Tin (0.5)				Tin (0.3)
	Outer Layer	Crystal Struc-	α:1001	a:1001	K: 401	a: 1001	a: 1001	α: 1004	a:1001	a:1001	K: 401	a:100%	a: 1001	α:1001	a: 1001	a:1001
	Outer	Compo- sition	A1203	A1203	A1203	A1203	A1203	A1203 (2.1)	A1203	A1203	A1203	A1203 (2.5)	A1203	A1203	A1203	A1203
	Second Intermediate Layer	Crystal Struc-	Granular	Granular			Granular	Granular	Granular	Granular	Granular		Granuler			
1	Sec Intern	Compo- eltion	T1CN0	T1CN0			T1C0	TiCNO (0.1)	Tico (0.1)	71C0 (0.1)	TiCNO (0.1)		T1CN0			
Hard Coating Layer	Pirst Intermediate Layer	Crystal Struc- ture		Granular	Granular	Granular		Granular			Grenuler			Granular		Granuler
lard Coa	Pi. Intern Lo	Compo- ition		Tic (2.8)	TiC (2.0)	TiC (3.0)		Tic (3.6)			TiN (1.8)			TiCN (1.2)		Tic (1.3)
	ayer	Orientation	(1111) (200) (220)	(220) (200) (111)	(111) (200) (110)	(1111) (022) (002)	(1111) (200) (220)	(320) (300) (111)	(1111) (022) (1111)	(111) (300) (110)	(111) (200) (111)	(111) (200) (111)	(1111) (002) (022)	(1111) (300) (330)	(220) (200) (111)	(1111) (2001) (1111)
	Inner Layer	Crystel Struc- ture	Granular	Granular	Granular	Granuler	Granular	Granuler	Granular	Granular	Granular	Granular	Granular	Granuler	Granuler	Granular
		Compo- ition	Tick (9.5)	TiCN (6.1)	TiCN (9.3)	TiCN (6.0)	TiCN (8.4)	TiCN (6.6)	11CN (8.7)	TiCN (9.8)	TiCN (2.5)	TiCN (7.7)	TiCN (6.3)	TiCN (2.4)	TiCN (8.2)	TiCN (6.9)
	Innermost Layer	Crystel Struc- ture	Granular		Granular	Granular		Granular	Granular		Granular	Granular	Grenuler	Gramiar	Granular	
	Inne	Compo- sition	Tin (1.0)		TiN (0.6)	Tin (0.5)		TiC- TiN (1.5)	TiN (1.7)		TiC (0.4)	TiN (0.5)	TiN 10.61	TiN (0.7)	T1CN (0.5)	
ġ	Symbol		٧	٧	٧	4	8	æ	æ	د	3	J	a	۵	٥	Q
			99	100	101	102	101	104	105	901	101	8 01	109	011	Ξ	TI.
	Туре							Costed Cesented Cerbide Outting	Tools of Prior Art							

1	мевг		Interruped cutting	Failure after 8.0 ain. due to Precturing	Failure after 7.6 min. due to Fracturing	Fellure atter 3.1 ein. due to Frecturing	Failure after 6.3 min. due to Fracturing	failure after 5.0 min. due to Frecturing	Failure after 4.5 min. due to Fracturing	Failure after 7.4 min. des	Failure atter 7.9 min. due to Fracturing	feilure efter 5.2 min. due to frecturing	(Chipping)	(Chipping)	(Chipping)	(Chipping)	(guing) ing)
	Flank Wear	(mm)	Continuous	Failure after 13.6 min. due to Chipoing	2 3	Failure after 14.4 min. due to Layer Seperation	Fallure after 15.1 min. due to Layer Separation	Failure after 17.4 min. due to Chipping	Failure after 16.3 mln. due to Layer Separation	Failure after 13.5 min. due to Chipping	Failure after 13.3 min. due to Layer Separation	Failure effer 17.6 ain. due to Layer Separation	Ξ	0.37 (Chippi (Hilling)	0.33 (C)	0.38 (Chippi	0.36 (Chipping) (Hilling)
		Outermost Layer	Crystel Struc- ture	Granular	Granular		Granular		Granular	Granuler			Granular		Cranular		Granular
		Oute	Compo- sition	TIN (0.2)	Tin (0.2)		TÎN (0.3)		TIN (0.4)	TIN (0.5)			TIN (0.3)		T1N (0.2)		118 (0.2)
		Outer Layer	Crystel Struc- ture	a:1001	a:1001	K: 401	a:1001	a: 1001	a: 1001	K: 404	a: 1001	K: 401	α: 1001	a:1001	a:1001	a:1001	α:100 1
		Outer	Compo- eltion	A1203	A1203 (0.7)	A1203 (1.5)	A1203 (1.2)	A1203	A1203	A1203	A1203 (1.2)	A1203	A3203	A1203	A1203	A1203	A1203
		Second Intermediate Layer	Crystel Struc- ture	Granular	Granuler			Oranular	Granulas		Granular			Granuler	Granuler		Granular
	זנ	Sec Inters	Compo- eltion	71C0 (0.1)	TiCNO (0.2)			T1C0	Tico (0.1)		T1CNO (0.1)			T1CN0	TICNO (0.1)		TiCNO (0.2)
TABLE 21	Hard Coating Layer	Pirst Intermediate Layer	Crystal Struc. ture	Granular		Gramler				Granuler	Granular			Granular		Gramlar	
TAE	ard Coa	Pi Intera La	Compo- sition	Tick (1.5)		TiCN (1.2)				TİN (1.8)	T1C (2.8)			TiC (1.5)		TiCN (0.9)	
		.ayer	Orlentation	(1111)	13301 (3001 (1331)	(111) (200) (230)	(111) (320) (300)	(1111) (200) (230)	(111) (001) (011)	(111) (111)	1022) (300) (1111)	(330) (300) (1111)	101211000111111	1111) 1002) 1022)	(022) (002) (1111)	(1111) (002) (022)	(1111) (200) (230)
		Inner Layer	Crystel Struc- ture	Grenuler	Granular	Granular	Granular	Granular	Granuler	Gramilar	Granular	Granular	Granuler	Grenuler	Gramler	Granular	Granular
			Comps- strion	TiCN (3.2)	TiCN (2.1)	TiCN (6.5)	TiCN (4.6)	TiCN (3.5)	TiCN (7.0)	TiCN (3.1)	T1CN (3.3)	T1CN (4.5)	TiCN (3.2)	TiCN (2.6)	TiCN (3.5)	TiCN (3.0)	TiCN 12.9)
		Innermost Layer	Crystal Struc- ture	Granular	Granular			Granular	•	Granular			Grenuler	Granular	Crenuler		Grenuler
		Inne	Compo- eition	TiN (0.3)	TIN- TICN (0.9)			TiC- TiN (1.0)		TiN (0.6)			TiCN (0.5)	TiN (0.3)	1 iv		7ic (0.8)
	ġ	Symbol		.	Ŀ	i.	la.	U	o	U	o	v	۵	ω	3	ü	ù
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		Type							Carbide Outing	Tools of Prior Art				•]

Claims

1. A coated hard alloy blade member comprising a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, characterized in that said hard coating includes an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al₂O₃ having a crystal form x or x + α wherein x > α.

- 2. A coated hard alloy blade member according to claim 1, wherein the TiCN in said elongated crystals of said inner layer has X-ray diffraction peaks such that strength at (200) plane is weak compared to strengths at (111) and (220) planes.
- A coated hard alloy blade member according to claim 1 or claim 2, wherein said hard coating further includes an innermost layer of one or more of granular TiN, TiC, or TiCN formed underneath said inner layer.
- 4. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further includes an outermost layer of one or both of granular TiN or TiCN formed on said outer layer of Al₂O₃.
 - 5. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further includes a first intermediate layer of one or more of granular TiC, TiN, or TiCN formed between said inner layer of TiCN and said outer layer of Al₂O₃.
 - 6. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further includes a second intermediate layer of one or both of TiCO or TiCNO formed between said inner layer of TiCN and said outer layer of Al₂O₃.
 - 7. A coated hard alloy blade member according to any one of the preceding claims, wherein said inner layer of TiCN further includes one or more layers of TiN such that the inner layer is divided by the layers of TiN.
- 8. A coated hard alloy blade member according to any one of the preceding claims, wherein said WC-based cemented carbide consists essentially of 4 12 % by weight of Co, 0 7 % by weight of Ti, 0 7 % by weight of Ta, 0 4 % by weight of Nb, 0 2 % by weight of Cr, 0 1 % by weight of N, and balance W and C.
- 9. A coated hard alloy blade member according to claim 8, wherein the maximum amount of Co in a surface layer of the substrate ranging up to 100 μm depth from a surface thereof is 1.5 to 5 times as much as the amount of Co in an interior 1 mm deep from the surface.
- 10. A coated hard alloy blade member according to any one of the preceding claims, wherein said TiCN-based cermet consists essentially of 2 14 % by weight of Co, 2 12 % by weight of Ni, 2 20 % by weight of Ta, 0.1 10 % by weight of Nb, 5 30 % by weight of W, 5 20 % by weight of Mo, 2 8 % by weight of N, optionally no greater than 5 % by weight of at least one of Cr, V, Zr or Hf, and balance Ti and C.
- 40 11. A coated hard alloy blade member according to claim 10, wherein hardness in a surface layer of the substrate ranging up to 100 μm depth from a surface thereof is more than 5% harder than hardness of an interior 1 mm deep from the surface.
 - 12. The use of a hard coated blade member according to any one of the preceding claims in cutting tools.

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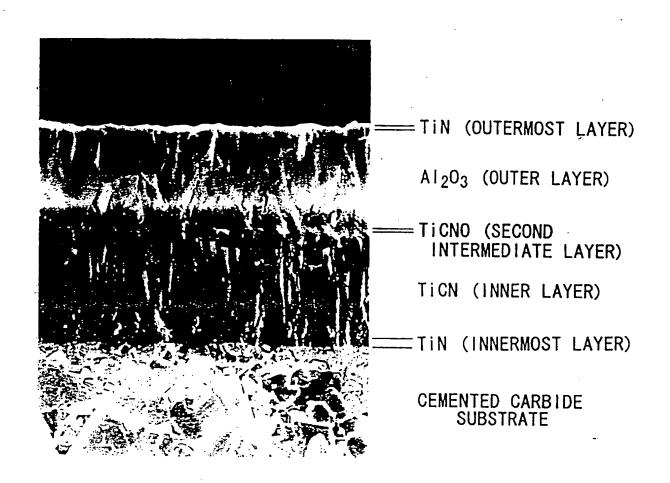


FIG. 1 COATED CEMENTED CARBIDE CUTTING TOOL "64"



EUROPEAN SEARCH REPORT

Application Number EP 95 10 3339

		IDERED TO BE RELEVAN		m .go
Category	Citation of document with of relevant p	indication, where appropriate, assages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CL6)
Y	1988	F JAPAN (C-552), 14 December HITSUBISHI METAL CORP),	1,3,12	C23C30/00 C23C16/40 C23C16/36
Υ .	PATENT ABSTRACTS 01 vol. 018, no. 392 ((C-1228), 22 July 1994 MITSUBISHI MATERIALS	1,3,12	
A	EP-A-0 594 875 (MIT 4 May 1994 * claims 1,2; table	SUBISHI MATERIALS CORP)	1-12	
Α.	EP-A-0 408 535 (SEC 1991	CO TOOLS AB) 16 January		
P,X	Class LO2, AN 94-25 XP002007194	S Ltd., London, GB; 19893 MITSUBISHI MATERIALS 14	1,12	TECHNICAL FIELDS SEARCHED (Int.Ct.6) C23C
	Place of search	Date of completion of the search	<u> </u>	Dominer
•	THE HAGUE	1 July 1996	Pat	terson, A
X : part Y : part focu A : tech O : non-	CATEGORY OF CITED DOCUME icularly relevant if taken alone icularly relevant if combined with an iment of the same category nological background—written disclosure mediate document	É : earlier patent doc after the filing da	nument, but publicate the application or other reasons	ished oa, or